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SCIENTIFIC REPORT

OF THE

Indian Agricultural Research Institute

FOR THE YEAR ENDING

30th June, 1958

PRINTED IN INDIA BY THE GENERAL MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI AND PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI, 1960

10 APR 1961

Price Rs. 8:00 *nP. or* 13 *Sh.*

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ANNUAL SCIENTIFIC REPORT OF THE INDIAN AGRICULTURAL RESEARCH INSTITUTE

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PREFACE

The Indian Agricultural Research Institute, now located at New Delhi and popularly known as the I.A.R.I. or "Pusa Institute", was originally established by the Government of India in 1905 at Pusa, a village in North Bihar. The establishment of the Institute was greatly helped by the benefaction of an American philanthropist, Mr. Henry Phipps, after whom the main laboratory building at Pusa, and later the laboratories of the Division of Soil Science and Agricultural Chemistry at New Delhi, have been named. The Institute was first named Agricultural Research Institute and it was later renamed Imperial Institute of Agricultural Research, Imperial Agricultural Research Institute and, finally, Indian Agricultural Research Institute.

The establishment of the Institute, in fact, marked the beginning of agricultural research on organised scientific lines in India. During the early years at Pusa, pioneering work was done at this Institute by eminent scientists, like J. W. Leather in agricultural chemistry, Edwin J. Butler in mycology and plant pathology, H. Maxwell-Lefroy and T. Bainbridge Fletcher in entomology and Albert Howard in the breeding of improved varieties of crop plants, including the famous "Pusa" wheats. In subsequent years, notable work was done in sugarcane breeding by T. S. Venkataraman at the Sugarcane Breeding Sub-station, Coimbatore (South India), which until recently formed a part of this Institute. The "Co." varieties of sugarcane bred by him are known all over the world. The most notable recent achievement of the Institute has been the production of a series of improved, disease resistant wheat varieties (now well known as the New Pusa or "N.P." wheats). In the course of the development of this Institute, the expansion of research in some crops resulted in the establishment of new institutes. The foundation of research in cotton, silk, lac, tobacco, potato and sugarcane in India was first laid by this Institute which nursed the research activities in these subjects till they were later taken over, each by a separate research organisation, such as the Bhagalpur Silk Institute, Bhagalpur (Bihar), the Indian Lac Research Institute, Ranchi (Bihar), the Central Tobacco Research Institute, Rajahmundry (Andhra Pradesh), the Central Potato Research Institute, Simla (Punjab) and the Sugarcane Breeding Institute, Coimbatore (Madras State). The organisation of research in cotton was taken over by the Indian Central Cotton Committee, Bombay, in 1921.

The great earthquake of Bihar in 1934 caused considerable damage to the Institute's buildings and properties at Pusa. It was then decided to shift the Institute to its present site in New Delhi. The transfer was completed in 1936. Here the Institute stands today, a beautifully-laid-out, 1100-acre colony, about 4 miles west of the New Delhi railway station. The latitude is 28·4° N, the longitude 77·10° E, and elevation above mean sea level 750·046 ft. The maximum and the minimum temperatures during the year range between 52·6° F and 116·0° F and 30·0° F and 91·8° F respectively, and the average annual rainfall is about 23 inches, of which about 2-3 inches are received during the winter months. The soil type is light, sandy to clayey loam.

Since 1945, and especially after Independence, the Institute has expanded considerably its facilities of expert staff, buildings, equipment and experimental fields. It is today regarded as the premier institute in

which there exist the best facilities that are available in the country for the conducting of basic and applied research in almost all the major disciplines of agricultural science and for imparting post-graduate training of the highest order in these disciplines. The Institute is under the direct administrative control of the Union Ministry of Food and Agriculture and works in close co-operation with the Indian Council of Agricultural Research (commonly known as the I.C.A.R.) which is concerned with promoting, co-ordinating and financing research schemes on agriculture and animal husbandry in India.

The five Sections of the Institute which were in existence at the time of the transfer from Pusa, have grown into the full-fledged Divisions of Agronomy, Botany, Entomology, Mycology and Plant Pathology, and Soil Science and Agricultural Chemistry. The Division of Agricultural Engineering was established in 1945. A section of Horticulture was started in the Division of Botany in 1954 and in 1957 it became a separate Division of Horticulture. Thus the Institute now has seven major Divisions, each under a Head of the Division. The over-all charge of the Institute vests, since 1945, in a full-time Director who is assisted by a part-time Joint Director and the administrative staff of the directorate. In 1958, the All-India Soil and Land Use Survey started functioning as a separate unit of the Institute, under the charge of the Chief Soil Survey Officer. The Institute has under its control a total of 11 sub-stations located all over the country, excluding the 19 regional soil testing laboratories so far established and the centres and sub-centres set up in the country under the Co-ordinated Maize Breeding Scheme, the work under which the Institute helps to co-ordinate on behalf of the I.C.A.R.

Each of the Divisions, except at the moment the Division of Horticulture, is housed in separate buildings, each one complete with laboratories, glass houses, workshops, etc. and research and auxiliary staff. The I.A.R.I. Library, possessing over 150,000 books and about 1200 periodicals, is considered to be the biggest agricultural library in India. The Division of Agronomy has bred, and maintains, a Sahiwal herd of milch cows which is regarded as one of the most-consistent performing herds of the world. In the Division of Botany, extensive living collections of crop plants and related species have been built up with the assistance of the Plant Introduction and Exploration Organisation located in that Division. The programme of mutation research under way in that Division would receive a great fillip when the "Gamma Garden" with its powerful 200-curie source of radioactive cobalt-60, starts functioning next year. A valuable National Pusa Insect Collection is housed in the Division of Entomology, and the mycological herbarium (*Herbarium Cryptogammae Indiae Orientalis*) and the Indian Type Culture Collection of fungi and bacteria, in the Division of Mycology and Plant Pathology. The Radio-tracer Laboratory is attached with the Division of Soil Science and Agricultural Chemistry; also located in that Division is the Cartographic Laboratory and the co-ordinating centre of the all-India chain of soil testing laboratories.

Besides its regular programme of research, the various Divisions of the Institute operate a number of research projects financed either by the Ministry of Food and Agriculture itself or by bodies like the Indian Council of Agricultural Research. These include, besides several others, a project on all-India trials on fertiliser and land use and a Co-ordinated Maize Breeding Scheme dealing with research on hybrid maize. In recent years

the Institute has been entrusted, on an increasing scale, with the co-ordination of research projects on a regional basis and in several such projects it is receiving the excellent co-operation of foreign organisations like the Indo-U.S. Technical Co-operation Mission and the Rockefeller Foundation. In an effort to carry the fruits of research to the farmers, the Institute is carrying out, since 1950, extension work in a block of villages in Delhi State under its Delhi Intensive Cultivation Scheme.

Post-graduate training constitutes an important part of the Institute's activities. Besides short-term and refresher-courses, regular 2-year courses in the major disciplines of agricultural science, leading to the award of the Diploma of Associateship of the Institute, are being given at the Institute since 1923. The Post-graduate Students' Hostel has 200 residential rooms. The present system of post-graduate instruction would shortly be reorganised when the Institute is accorded the status of an University for organising courses of instruction leading to the award of the M.Sc. and Ph.D. degrees. The Rockefeller Foundation has offered its generous co-operation in this educational project.

The Institute is annually visited by numerous visitors—dignitaries, administrators, scientists and farmers from within the country as well as from abroad. They have all been appreciative of the unique research facilities obtaining here and also of the efforts made by the Institute in the service of Indian agriculture.

REPORT OF THE DIRECTOR

1. INTRODUCTORY

The year under report saw much progress in the research activity and in the training programme of the Institute. Considerable headway was made in the preparations for the establishment of the Post-graduate School as per recommendation of the Indo-U.S. Team on Agricultural Education. The School is expected to start functioning in October, 1958.

Progress was also made in the establishment of a "Gamma Garden" at this Institute for mutation research. For this purpose, a powerful 200-curie Cobalt-60 source will be installed in the centre of a 3-acre circular plot. The field irradiation unit is expected to arrive late in 1958 and the Atomic Energy Establishment at Bombay has kindly agreed to fabricate the actuating mechanism for automatically raising and lowering the radiation source by means of electronic devices.

A short training course on radio-tracer techniques was organised this year also, in the Division of Soil Science and Agricultural Chemistry, for the benefit of the trainees deputed by the State Departments of Agriculture and Central Research Institutes. The All-India Soil Survey Scheme of this Institute was integrated with the Land Utilisation Survey Scheme of the Central Soil Conservation Board; the integrated scheme is now known as the All-India Soil and Land Use Survey; it will constitute a separate unit under this Institute. The survey aims at carrying out a comprehensive programme of all-purpose survey and soil mapping on the basis of uniform methods of soil survey and soil correlation.

Fifteen soil testing laboratories have so far been set up at different locations in India under the Institute's Soil Testing Service, which aims at advising the cultivators on the manurial and fertiliser requirements of crops based on the analyses of soils from cultivators' fields carried out by these laboratories. In this important project, the U.S. Technical Co-operation Mission are assisting by way of providing equipment and soil testing advisers.

Further progress was made in the research on hybrid maize under the all-India Co-ordinated Maize Breeding Scheme sponsored by the Indian Council of Agricultural Research in which project the Rockefeller Foundation is actively co-operating; the main centres and sub-centres under the scheme started functioning during the year under report.

A useful procedure being adopted at this Institute relates to the holding of annual conferences of research workers, especially in respect of projects in which the Centre and the States participate and which the Institute co-ordinates. These meetings are valuable as they provide an excellent forum for detailed discussions on the progress of work, methods and techniques and future programme of work. During the year under report, agricultural chemists, agronomists, statisticians and regional fertiliser officers held joint discussions on soils and fertilisers and all-India agronomic trials. In another conference, maize breeders in the country met to consider the progress of the hybrid maiz programme.

Among important changes in the staff may me mentioned the filling up of the post of Head of the Division of Horticulture by Dr. S. Krishnamurthi. Dr. S. M. Sikka left the Institute on the 1st June, 1958, to take up his appointment as Additional Agricultural Commissioner with the Government of India. His departure has been a great loss to the Institute.

On the occasion of Republic Day, the Director, Dr. B. P. Pal, was honoured by the award of the Padma Shri to him by the President of India.

2. SUMMARY OF THE MAIN RESULTS OF THE RESEARCH

Division of Agronomy

Field investigations were conducted in soil fertility on field, vegetable and commercial crops, on farm operations and in relation to the Sahiwal herd of milch cows. Under the research schemes the investigations related to irrigation, weed control, plant tissues tests and spray fertilisation, and to the all-India co-ordinated complex and simple fertilizer trials on cultivators' fields.

Soil Fertility.—A long-term experiment was started to compare, under a fixed rotation the effect of green manure, oil cakes, farm yard manure and fertilizers on soil fertility. Green manuring with hubam clover, after a dressing of phosphate to the soil, helped to obtain a grain yield of 42 md. from the following maize crop as compared to 36 md. when hubam was allowed to seed. When hubam was cut for fodder once, twice or thrice and then green-manured, the succeeding maize crop, inoculated with Fospho-24 in combination with 60 lb. N + 30 lb. P_2O_5 as bonemeal or rock phosphate, gave an increased yield of 5½ md. over the treatment in which the fertilizers alone (without Fospho-24) were applied. Fospho-24, phosphobacterium (Russian Culture) and Indian bacterial cultures, in combination with nitrogen, did not show superiority over nitrogen treatment alone.

Field crops.—Response curve studies, with nitrogen doses, on the N.P. wheat varieties, 710, 718, 720, 792 and 799, indicated significant interaction between varieties and doses of the fertilizers; comparatively higher response was exhibited by N.P. 718 and N.P. 792. Application of nitrogen, on equivalent nitrogen basis, using ammonium sulphate, ammonium nitrate and chilean nitrate did not result in any significant difference in the yield of the wheat crop, although the application of both 20 lb. and 40 lb. nitrogen increased the wheat yield over the unfertilised control. Experiments on these lines in linseed gave similar results. The application of superphosphate 3 in. below the seed line in a single band increased the yield of wheat by 3·4 md. per acre (31·6 per cent.) compared to that obtained by the surface application of the fertiliser; these results were confirmed by radio-tracer studies. In paddy, it was interesting to observe that a 6·1 md increase in yield per acre was obtained by earthing up the crop as compared to raising it in flat beds.

Among forage crops, a strain of hubam clover (A. 3102) introduced from Israel, maintained greenness for a much longer period than the other strains and it seems promising as a material for building up soil fertility and fodder production.

Vegetable and commercial crops.—The maximum yield of 224·3 md. per acre was obtained in cauliflower by the application of 120 lb. N and 80 lb. P_2O_5; the response curves were linear for the various doses of both nitrogen and phosphate, and the application of molybdenum did not increase the yield. In tomato, significantly increased yields were obtained by the application of graded doses of nitrogen and phosphate; 90 lb. N plus 60 lb. P_2O_5 gave the maximum yield (297·6 md.). Plough-sole placement of fertilizer resulted in significantly increased yields in the cotton crop as compared to broadcast application of nitrogen alone, or of nitrogen in combination with phosphate. The sugarcane variety, Co. 647, gave the highest yield of 847.4 md. per acre as compared to 643.6 md given by Co. 312; the responses given by 40, 80 and 120 lb. doses of nitrogen were, respectively, 43·3, 73·6 and 137·5 md. of stripped cane.

Farm and cattle.—The net receipts from the farm and dairy, during the year under report, were Rs. 95,902. 2158 mds. of nucleus seed of improved New Pusa varieties of wheat, produced on the farms of the main Division at Delhi and the Agricultural Research Sub-station, Karnal, were made available for distribution.

The milking-average and the overall average yields of the Sahiwal herd were 21·8 and 12·3 lb. respectively, per day, with 39 cows in the herd. Eleven bulls were sold to State Governments for upgrading their milch cattle stocks. In the feeding experiment on calves, it was finally shown that similar growth rates were shown by calves fed on standardised milk as compared to those fed on skimmed milk; feeding with skimmed milk resulted in a 46 per cent. reduction in the cost of feeding.

Irrigation investigations.—The long-term experiments on the inter-relationship between cropping pattern and irrigation intensity were continued. The optimum yield of 726·9 md. of berseem fodder was obtained with 41 acre inches of irrigation. Wheat, sown on conserved moisture, gave significantly higher yield with 12 acre inches than with 9 acre inches of irrigation. In potato the yields, with 20, 28 and 36 acre inches of water, were 293, 299 and 325 md. respectively; the differences between the 20-and the 36-acre-inches treatments were significant.

Weed Control.—Complete control of *Sorghum halepense* (Baru grass) was brought about by a combination of 6 cultivations and 30 lb. TCA application to the fallow field in the summer season. Sodium ester and amine salts of 2, 4-D and sodium salt of MCPA were effective in controlling weeds in sugarcane; the broadleaved weeds killed were *Euphorbia* sp., *Corchorus* sp., *Digera arvensis*, *Celosia argentia*, *Phyllanthus niruri* and *Xanthium strumarium*. Post-emergence application of MCPB at 12 oz. per acre proved most effective in checking weed growth in the peas crop; a yield as high as 40·2 md. per acre was obtained in the treated plot, as compared to 19·4 md. obtained from the unweeded control plots.

Agricultural extension.—Preliminary work carried out in the Delhi villages under the Institute's Delhi Intensive Cultivation Scheme indicated that distribution of impressive posters conduced to a greater adoption of improved agricultural practices by the farmers, as compared to other extension methods, and also that this method was the least expensive. If cost was not the consideration, the demonstration method seemed to be the most convincing; however, the scope of adoption of this method was rather limited. The farmers of medium socio-economic status gave

greater co-operation in adopting improved agricultural practices than farmers of high, or low, socio-economic status.

Plant tissue tests and spray fertilizer application.—In tomato, spraying with triple superphosphate, at 20 and 40 lb. per acre, sprayed as a 2 per cent. solution, appeared to induce early setting and maturity of fruit; 30 lb. ., sprayed as 2 per cent. and 4 per cent. solution, gave yields of 151 and 142 md., respectively, per acre compared to 90 md. obtained through the so'. application of equivalent doses of nitrogen. Plant tissue tests conducted on wheat and *jowar* crops showed that a high status of nitrogen was obtained throughout the growth cycle in the case of wheat when 40 lb. nitrogen was applied to the soil and, in *jowar*, with a 60 lb. application of nitrogen.

All-India scheme of co-ordinated agronomic experiments.—The model agronomic experiments were carried out at 31 centres in 14 States in India, the total number of experiments conducted being 169. Eight hundred and forty-three trials were carried out, under the co-ordinated scheme of simple fertiliser trials in cultivators' fields, in the States of Kerala, Madhya Pradesh, Mysore, Orissa, Rajasthan and Punjab and in the Union Territories of Delhi and Himachal Pradesh. The data obtained from a series of simple and complex experiments, carried out in cultivators' fields during 1953—56 under the Fertilizer Use Project, were compiled and computed. The comparative response to urea almost equalled that obtained with ammonium sulphate. The average responses to 20 lb. N were 4·5 md. for paddy and 3·0 md. for wheat; these responses were almost halved by the application of a further dose of 20 lb. N. About 60 per cent. of the soils in India showed high response to phosphate application. The average response to a 20 lb. dose of P_2O_5 was 3.6 md. in the case of paddy and 2·3 md. in wheat. Response to nitrogen in wheat was much higher with irrigation than without it. It is more effective to apply nitrogen to the paddy crop in three split-up doses during the life cycle of the crop than the application of the full dose at transplanting time. In wheat, fertiliser application at sowing time proved to be as effective as the application of the full dose with the first irrigation.

Agricultural economics.—Under the Section of Agricultural Economics, which was set up late in the year, a project on farm planning and budgeting was initiated on 64 holdings of various sizes in 8 villages covered under the Institute's Delhi Intensive Cultivation Scheme. A preliminary survey of the villages lying within a radius of 5 miles from Fatehpur and covered by social welfare centres, indicated that landless labourers account for 47 per cent. of the population.

Statistics.—In a study on the heritability of milk yield, the intra-sire heritability for the Cello bull-line was found to be significant at the 10 per cent. level, the heritability co-efficient being 43 per cent. In respect of persistency in milk yield, highly significant correlations were found between the total lactation yield and the initial 8-week yield. Thus, the initial 8-week milk yield gave the best prediction of the total lactation yield. In the experiment, the high yielding cows appeared to be significantly more persistent than the low yielders.

Division of Botany

The research work of the Division continued under its four sections, namely, Plant Breeding and Genetics, Cytology and Cytogenetics, Crop Physiology, and Plant Introduction and Exploration.

Plant Breeding and Genetics

(i) *Breeding for disease resistance and other desirable characters in wheat.*—This work was in progress at Delhi and at the sub-stations at Simla, Pusa, Indore, Wellington and Bhowali. A large number of promising selections were made in the progenies of intervarietal and interspecific crosses, which combined in them rust resistance and desirable agronomic characters from diverse sources. At Delhi, some of the promising selections from the cross Rio Negro x N. P. 760 were found to possess good grain characters and field resistance to more than one rust.

The results of the yield trials with the newly-evolved varieties of the N. P. 800 series, conducted at various places, have indicated the superiority of N. P. 824 and N. P. 825 at Delhi, N. P. 824 at Pusa, N. P. 826 and N. P. 824 at Vijapur (Bombay State), N. P. 818 in the higher hills and N. P. 824 and N. P. 829 in the lower hills of Punjab and Himachal Pradesh. The varieties, N. P. 797, N. P. 798 and N. P. 799 continued to show superior performance in Bihar. In the hills, N. P. 770, N. P. 809 and Ridley were again found to be superior. At Wellington, a new variety, N. P. 200, has been evolved which is superior to the local Samba wheat (*Triticum dicoccum*) with regard to yield, grain quality and nutritive value; besides, it shows considerable field resistance to the black and brown rusts. N. P. 200 is now being recommended for general cultivation in the hilly areas of South India.

The increasing popularity of "N. P." wheat varieties among cultivators has resulted in a heavy demand for their seeds. During the year, the total demand for seeds was 11,430 mds., but only about 2,420 mds. could be supplied from the stocks at the Institute and its sub-stations because of the limited area available for seed multiplication.

(ii) *Hybrid maize.*—Among the several hybrids tested for performance, the locally-produced double cross, (T61 × Hy) × (My B-I × P4 A (y)-3Y), gave the best performance; it yielded 120 per cent. more than the control open-pollinated variety, K. T. 41. Among the exotic hybrids, Oh. 7 x C. I. 21E, Texas 32, Funks 54188 and Texas 26, appeared promising, giving respectively 110 per cent., 71 per cent., 116 per cent. and 92 per cent. higher yields than the check, K. T. 41.

(iii) *Hybrid jowar.*—Among the fertile F hybrids obtained by crossing the male-sterile line, Texas Blackhull Kafir, with a number of indigenous strains, the hybrid with I. C. 3437 gave the maximum grain yield increase of 89·82 per cent., as compared to the mean of the two parents and 36·94 per cent. over that of I.C. 3437, the higher yielding parent. A cytoplasmic male-sterile line has been developed in the indigenous type, I. C. 2360. This cytoplasmic male-sterile line has much promise in the production of hybrid *jowar* seeds as, unlike the Texas male-sterile line, it possesses all the desirable plant characters, including grain quality, and hence could be used directly in the hybrid programme.

(iv) *Bajra.*—Two exotic varieties, E.C. 11793 and E.C. 11794 received from Ghana, were found to be promising early types possessing bold grains. In the hybrid *bajra* programme, the best two among the top-crosses, *viz.*, (1724/2-1 × T. 55) and (1724/1-3 × T. 55), gave calculated grain yields of 1405 lb. and 1414 lb. respectively, as compared to 1037 lb. per acre from the check variety, T. 55.

(v) *Rust resistant linseed.*—Five newly-evolved rust resistant selections, *viz.*, S208, S273, S218, S214 and S209, were found to be earlier in maturity than, and statistically at par in respect of yield with, the controls N. P. (R. R.) 9 and H. 514-1; the latter variety, from U.P., is a high yielder but is rust-susceptible.

(vi) *Wilt resistant arhar.*—In replicated progeny-row tests, a number of newly-evolved, early-maturing, wilt resistant strains, such as S. 68, S. 76 and S. 37 gave gratifying yield performances. They yielded better than the control, N. P. (W. R.) 15, and at par with the U. P. Type 105, under non-wilt-stick conditions; U. P. Type 105, however, is wilt-susceptible.

(vii) *Cotton* (*Gossypium hirsutum*).—An extensive collection of foreign *hirsutums* is being built up and evaluated. Some stocks from the U.S.A. and the U.S.S.R. appear to be promising from the standpoint of their utilisation in breeding for improved staple length and ginning out-turn.

(viii) *Chilli.*—The high resistance of "Puri Red" to the mosaic virus was further established under controlled conditions of inoculation. The F hybrid, N.P. 46 × Puri Red, appeared to be resistant, suggesting the dominance of resistance.

(ix) *Essential-oil bearing plants.*—Work on the improvement of *ajwain*, coriander, cumin, dill and fennel was continued for the third year at all the four centres, namely, Delhi, Jamnagar, Pusa and Katrain.

Some of the selections made in the various crops were observed to give 100 to 400 per cent. higher yield than the control variety. Some selections gave high oil-content also.

(x) *Vegetables.*—Work on the improvement of vegetable crops was continued at Delhi and at the Vegetable Breeding Sub-station, Katrain. The important results in some of the vegetable crops are given below:—

(a) *Lady's finger.*—A significant achievement was the evolution of yellow-vein-mosaic resistant, high yielding varieties of *bhindi*. Four mosaic resistant cultures were selected for seed multiplication.

(b) *Tomato.*—In a preliminary trial of F. tomato hybrids, five hybrid combinations have given 25 to 50 per cent. more yield of fruit as compared to the corresponding higher yielding parents; the latter are themselves high yielding varieties.

(c) *Sweet-potato.*—A red-skinned and white-fleshed selection from the original stock of the variety, Norin, has given high yields and is now being multiplied. This will meet the demand for a good red-skinned variety.

(d) *Water-melon and musk-melon.*—Some of the Japenese varieties of water-melon, such as Giant Shin Yamato and Nagaoka Fukin, again showed higher sugar content (12 per cent. total sugar) and very good bearing as compared to indigenous varieties. In musk melon, true breeding lines possessing good bearing and high sugar content have been isolated for increasing the seed.

(xi) *Algae.*—The rare and little known alga, *Botrydium divisum,* was collected and a complete study of this alga was carried out. A new terrestrial species of *Oedogonium, Oe. randhawae* sp. nov., was described in detail. A *Nostoc* strain isolated from the root nodules of Egyptian clover has been found to fix elementary nitrogen. In this alga, it was found that, of the total nitrogen fixed, about 80 per cent. is liberated into the medium in the form of extracellular nitrogen; by increasing the concentration of molybdenum, not only was it possible to enhance the nitrogen fixation, but the period during which extra-cellular nitrogen is liberated could also be considerably prolonged.

Cytology and Cytogenetics

(i) *Induced polyploidy as a means of crop improvement.*—Autotetraploids of *toria* continued to yield well when compared to the diploids. At Delhi and at Pusa they yielded 16 to 20 per cent. over their controls. In Himachal Pradesh, the tetraploids yielded well only under irrigated conditions. The polycross method of breeding was adopted in tetraploid berseem to bring about further improvement in fodder yield and seed fertility. Induced tetraploids of phlox, carnations, cosmos, petunia and marigold were found to have larger and more showy flowers than the diploid parents.

(ii) *Induction of mutation in crop plants.*—The bearded mutations induced in the wheat varieties, N.P. 797, N.P. 798, N.P. 799 and N.P. 809, were found to breed true. By studying the F_1 and F_2 crosses between the parent strains and the bearded mutants, it was found that the mutants behave as monogenic recessives. Several stiff-strawed and rust resistant mutants were isolated in the variety, C.591. Besides radiations, oils such as groundnut oil and castor oil were also found to induce viable mutations in wheat. Promising mutations were also obtained in tomato, tobacco and several ornamental plants.

(iii) *Culture of excised plant embryos.*—Somatoplastic sterility was found to be responsible for the abortion of young embryos in the cross, *Corchorus olitorius* x *C. capsularis.* Suitable media were standardised to culture ovules and young embryos of *C. olitorius.* The addition of gibberellic acid (1 ppm.) was found to induce a marked stimulation in the growth of young embryos.

(iv) *Monosomic analysis in wheat.*—By analysis of F_2 segregations in the cross between the variety Cometa Klein and Chinese Spring monosomes, it was found that chromosome IX of Cometa Klein carries the gene for resistance to race 13 of yellow rust and chromosoms IV and VI for resistance to race H.

Crops Physiology

Spraying the cotton crop with synthetic growth-regulators, such as, alpha-naphthalene acetic acid, beta-indole acetic acid, indole butyric acid and beta-naphthoxy acetic acid, soon after the first opening of flowers, was found to give significant increases in the yield of seed cotton (variety, 216F). This observation has been confirmed during the last three seasons. Beta-naphthoxy acetic acid, at a concentration of 5 ppm, with wetting agent, was found to be most economic substance to use.

Plant Introduction:

During the year, 1298 samples of seeds and planting materials were introduced from abroad and 1441 seed samples were collected from within the country. About 60 varieties of wheat and barley were received through the Food and Agriculture Organisation.

A survey was undertaken to collect drought-resistant and salinity-tolerant plants from the saline regions of Rajasthan. Wild-growing legumes, grasses and allied species of cultivated plants were collected from the hilly areas of Orissa and Mysore States.

The low-growing legume, *Desmodium paleaceum* (EC 2970), from Nigeria has been observed to tolerate frost and summer heat. Chemical analysis of its green matter showed that it has high nutritive value. A functional male-sterile (closed anther) line of brinjal was obtained from Canada. It has been utilized in the hybrid seed production programme. The tomato varieties, Dublin's Choice (E. C. 1138), Tuch Queen (E. C. 9147) and Giant Tziar (E. C. 9684), showed mosaic tolerance under field conditions.

Division of Entomology

Insect Taxonomy.—Studies on the taxonomy of a genus of tree-hoppers indicated the need for changes in the systematic position of the genus. Five new species of tree-hoppers and two new species of plant lice were described. Biometric studies on the sweet potato weevil showed that two distinct strains existed within the species. A new species of plant bug (Neididae) was described.

Insect Parasitology.—Out of 27 species of parasites bread, 5 were new. Studies on the effect of nutrition on the growth of the rice moth, whose caterpillars were utilised as alternate hosts for breeding parasites, indicated that crushed *jowar* was best out of the six diets tried. Studies on resistance of beneficial insects to insecticides (p-p' DDT and lindane) showed that the mortality response of a parasitic wasp (*Bracon brevicornis*) was higher at higher temperatures and higher relative humidities. Resistance was developed more at 75 per cent. R. H. than at 65 per cent. or 85 per cent. R. H.

Ecology and Toxicology.—Studies on the tolerance of the chalcid parasites (*Trichogramma* sp.) showed that development did not take place when host eggs parasitized by this chalcid were exposed to 45°C. and 75 per cent. R. H. for 2 hours or more. Eight generations of the painted bug were successfully reared at room temperature in summer on soaked mustard seeds. A study of the brood rearing cycle of Pusa bees (at Pusa, Bihar) showed that the maximum brood area in a colony was 400 sq. inches during February which gave a laying capacity of 821 eggs per day during the peak period.

Out of 11 insecticidal emulsions tried, parathion was found to be the most toxic against freshly hatched larvae of pink bollworm. Against 'Phadka' egg pods, buried in earthen pots, 10 % chlordane dust applied at 40, 50 and 60 lb. per acre was found to be quite effective.

Fumigation of the rust and flourbeetle in an empty space showed that carbon disulphide was most effective followed by EDCT mixture and carbon tetrachloride. In the presence of commodities, on the other hand, the relative efficacy was in the following order: carbon disulphide,

carbon tetrachloride, ethylene dichloride, carbon tetrachloride mixture, and ethylene dichloride. Carbon tetrachloride gave an almost complete kill of the important storage pests except Khapra grubs when used either at 10 lb/1,000 cu.ft. for 24 hours or at 7½ lb/1,000 cu.ft. for 48 hours. Carbon disulphide could kill all the stages of bruchids when used at 20 mg./litre for 24 hours. Larvae of rice moth were found to sorb the largest amount of hydrocyanic acid gas, followed by bruchid adults, Khapra larvae and rice weevil. The relative toxicity of different fumigants to the mango mealy bug was in the following order: hydrocyanic acid gas, methyl bromide, Acrylonitrile : CCl : 1 : 1 (Acrylon), carbon disulphide + ethylene dibromide, carbon disulphide, and carbon disulphide + carbon tetrachloride.

Experiments on the control schedule for mustard crop showed that the highest degree of aphid control was achieved in the plots treated with parathion, followed by DDT — BHC mixture, gamma BHC, diazinon malathion, nicotine sulphate. In experiments on the control schedule for the maize crop, in two out of three sprayings, gamma BHC significantly reduced the population of the stem borer. The effect of endrin sprays on the balance of pest population in the cotton crop was that, after the fifth spraying, the population of jassids, thrips, white flies, mites, aphids and spotted bollworm was reduced by 65 per cent., 91 per cent., 98 per cent., 39 per cent., 99 per cent. and 94 per cent., respectively, whereas that of pink bollworm increased by 19 per cent.

Insect Physiology.—A technique was evolved to rear hollworm of cotton in large numbers under laboratory conditions. The larvae of *jowar* stem borer and potato tuber moth were reared successfully up to the adult and pupal stages, respectively, on synthetic diets. It was found that for the development of Khapra larvae, nicotinic acid, pantothenic acid, choline chloride, riboflavin and thiamin, and for the larvae of the rust red flour beetle, nicotinic acid, pantothenic acid and aneurin (thiamin), were most essential. In nutritional studies on fruit flies, the *Luffa*-yeast-agar medium proved better than *Luffa*-agar alone.

Investigations with the help of radioactive isotopes.—There was no significant effect of beta radiations (^{32}P) used at the rate of 1600, 800 and 400 mrep/hr. on the fecundity, viability and development of freshly laid eggs of the parasite, *Bracon gelechiae*. In the case of its laboratory host, the rice moth, it was observed that the viability of eggs and percentage of successful completion of development were significantly more in the case of 1111 mrep/hr. dose than in 555, 2222 and 3333 mrep/hr. dosages and control. The effect of irradiation on the larvae of rice moth showed that the irradiated larvae completed development in all the treatments but the maximum number of individuals (85%) completed their development with 1111 mrep/hr. dose. Studies were also undertaken on the pick up and distribution of radioactive 'Schradan' in the body of adult red cotton bug.

Division of Mycology & Plant Pathology

Wheat

Fugal Diseases.

(i) *Rust.*—Four hundred and twenty-one samples of black, brown and yellow rusts of wheat were analysed and races 15, 15-C, 17—21, 21—A, 21—B, 24, 34, 40, 42—B and 122 of black rust, races 10, 11, 17, 20, 26, 63, 70, 77, 106, 107, 108 and 162 of brown rust and races 13, 19, 20, 31, "A" and "G" of yellow rust were met with. Races 42-B, 21

and 40 of black rust, races 20, 77 and 107 of brown rust and races 19, 31, 'A" and "G" of yellow rust were predominant, while races 17 and 162 of brown rust and race 21-B of black rust, first isolated from 1956-57 crop, appeared to be increasing in frequency.

Twenty-three species of *Agropyron* and *Aegilops* were tested with races 15-C and 122 of black rust of wheat, and a few of them were found to be resistant to either one or both the races.

In the seedling resistance tests the wheat variety, E.3123, was found to be resistant to all the individual races of black rust of wheat and the resistant to all the individual races of black rust of wheat and the varieties, E. 2125 and E. 3099, to all the individual races of brown and yellow rusts, respectively. In the tests with the mixtures of races of individual rusts, the wheat varieties E.2733, E.2537, E.3093, E.3158, E.3176 and E. 3236 were found resistant to black rust, E. 2733 and Hyb. 177-3-1 to brown rust, and E. 2096, E. 3066, E. 3067, E. 3076 and E. 976 to yellow rust.

Studies were continued on the survival of races, 21 and 40, of black rust of wheat in mixture on the wheat varieties—*Agra local*, Pb.C. 591. N.P. 4, N.P. 710 and N.P. 718 and the relative proportion of the two races was determined upto the ninth generation. It was found that race 40 increased in proportion as compared to race 21 on N.P. 4, N.P. 718, and Pb.C. 591, whereas in the case of N.P. 710 the position was just the reverse On *Agra local*, however, there was no change in the proportion of the two races.

Two colour mutants of race 194 of black rust of wheat were isolated. Also, indications of a third mutant in the same race, involving change in pathogenicity, have been obtained.

(ii) *Loose smut.*—Out of 48 varieties tested for their resistance to the disease at Delhi under field conditions, 21 remained free from smut infection. Amongst the smut-free varieties, E. 581, E. 2025 and E. 2140 have consistently remained free from infection during the last three years' tests. Infection obtained in some of the susceptible varieties was as high as 72—100 per cent.

(iii) *Bunt.*—Thirty-one wheat varieties got infected with Karnal Bunt out of the 162 varieties (including 52 of the last year) tested at both Delhi and Karnal. In similar tests with Hill Bunt at Simla, 18 varieties, out of 109 under test remained free from infection. Amongst the bunt-free varieties, E. 192, E. 197, E. 201, E. 2327 and Australian No. 1 had also remained free from infection in the last year's test.

(iv) *Powdery mildew.*—In the varietal resistance tests, khapli (*T. dicoccum*) was resistant. Twenty-four wild grasses were inoculated with the pathogen for host range and light infection was obtained only on *Avena glauca, Lolium temulentum* and *Aegilops* sp.

Barley

(i) *Rust.*—Twenty-four rust samples were analysed and races 15, 21, 34, 40 and 42-B of black rust and races 19 and "G" of yellow rust were encountered. In the seedling resistance tests, the barley varieties B. 267, B. 241 and N.P. 4 were found resistant to all the ten races of yellow rust individually and BH 4, 2, 3, pl 9, BH 4-2-4 pl 23 and BH 4-2-7 pl 3 to a mixture of the races. No variety was, however, found to be resistant to all the races of black rust.

Leaf rust of barley (*Puccinia hordei*) was again observed during this year in a severe form and observations were taken on 400 barley varieties under natural conditions of infection. One hundred and sixty varieties showed infection ranging from traces to moderate, while the varieties, B. 222, B. 223, N.P. 13 and N.P. 21 were heavily infected. Eight rust samples were analysed and a new race was isolated. Thus, two new races, provisionally designated as H1 and H2 (new race), and a biotype of the former (H1-A), have so far been picked up.

(ii) *Loose smut.*—Of the 31 barley varieties tested for their resistance to the disease under field conditions, only B57(S) remained free from infection. In some of the susceptible varieties, infection as high as 88 per cent. was obtained.

Sugarcane

(i) *Red Rot.*—Studies on physiologic specialisation of the pathogen did not reveal the occurrence of any specialised forms. Some of the recent isolates were, however, found to be more virulent than the earlier ones. In the varietal resistance tests with 199 promising cane varieties, Co. 312 reacted as moderately resistant in the Plug method of testing, while it was found to be resistant in the test using nodal infection.

(ii) *Smut.*—In the varietal resistance tests with 193 cane varieties, 21 gave less than 5 per cent. smut infection and may therefore be considered as resistant.

(iii) *Rust.*—The technique for maintenance of the rust on cut leaves and potted plants of sugarcane was standardised. It was found that the rust on sugarcane was morphologically similar to *Erianthus* rust, but differed from *Saccharum spontaneum* rust.

Linseed

(i) *Rust.*—Eighty-three rust samples, collected from different parts of the country, were analysed and all the five Indian races of *Melampsora* lini were met with. In the seedling resistance tests, E.6163 showed immunity.

Pigeon pea wilt

Twenty pigeon pea varieties were tested for their resistance to the disease. Three varieties, N.P. 41, S. 33-2 and S. 37-1, did not develop wilt symptoms.

Green ear of Bajra

In the experiments conducted to induce quicker and better germination of oospores, maximum germination was obtained when the material was buried in the field. In the varietal resistance tests, 8 *bajra* varieties, out of 20 under test under field conditions at Delhi, remained free from infection; the highest percentage of infection obtained in these tests was 28.5

Maize rust

Successful infection was obtained with the germinating teleutospores of *Puccinia sorghi* on *Oxalis corniculata*, thus establishing it as the alternate host of the rust.

Nitibioris.

The antibiotic production of *Bacillus subtilis* was considerably increased in sterilized soil supplemented with molasses or mustard cake and this was further enhanced by the addition of roots of some leguminous plants. The antibiotic principle was found to act systematically in pigeon pea plants.

PHYSIOLOGY OF FUNGI

Studies on the nutritional requirements of *Lophotrichus ampulus* showed that a medium, consisting of lactose, glutamic acid, magnesium sulphate, calcium chloride, trace elements, thiamine and biotin (neutral pH), supported very good growth and sporulation of the fungus when the cultures were incubated at 28—30°C.

Further work on the factors affecting the virulence of light and dark type isolates of *Colletotrichum falcatum* showed that addition of certain nitrogen compounds to the cane juice medium tended to increase the production of endoenzyme as also increase the virulence.

Effect of atomic radiations on fungi

Mutagenic effects of beta radiations from P^{32} on *Colletorichum falcatum* Went. were studied and a number of mutants of isolate No. 244 were picked up which showed variation in cultural and morphological characters as also in biochemical reactions. Further studies on the biochemical mutant obtained with the aid of P at an initial activity level of 240 microcuries per ml. showed that the vitamin, p-aminobenzoic acid, supported maximum growth and sporulation of the mutant, almost similar to those of the parent culture. It was proved that the parent culture synthesized its own requirement of p-aminobenzoic acid which could be inactivated by the addition of sulphanilamide.

Fungicides

Glycerol thiocyanoacetate exhibited good fungicidal properties when tested with spores of certain fungi. It was recorded that pre- and post-emergence damping off in chillies was reduced to 6.6 per cent., 6.3 per cent. respectively when seeds were treated with Flit 406, as against 40.8 per cent. and 79.2 per cent. in the untreated controls.

Seed treatment with New Improved Ceresan, Fusariol, Tritisan and Agrosan GN decreased the incidence of Hill Bunt of wheat to less than 2 per cent. as compared to 76·2 per cent. in the control. All the nine seed dressing fungicides (N. I. Ceresan, Ceresan, Lunasan, Fusariol, Harvesan, Tillex, Agrosan GN, Agrosan 5W and Flit 406) tried for the control of stripe disease of barley showed beneficial effect in reducing infection and increasing germination of seedlings. Agrosan 5W and Ceresan M successfully controlled covered smut of barley, whereas Agrosan 5W reduced the infection of stem rot of jute from 45.3 per cent. to 7.0 per cent.

Bacterial and nematode diseases

In the varietal resistance tests against bacterial leaf spot of chilli (*X. vesicatoria*), the chilli varieties Kondevaram, Bombay 469, N.P. 10, Patna and Suryamukhi Red Erect, were found to be resistant. "Molya" disease was found to be causing severe damage to the wheat and barley

crops in Rajasthan and pathogenicity of *Heterodera* sp., associated with the trouble, was established under glasshouse conditions.

Virus diseases

Further evidence regarding the presence of "Tristeza" virus, causing 'Quick-decline' in citrus, was obtained. The virus was transmitted to West Indian Key-Lime and *Aegilopsis chivalieri* by tissue grafting and through the vector, *Toxoptera citricidus*. Mango malformation, yellow mottle of Red Gold apple and mosaic of Golden Delicious apple were established to be of virus origin. The virus, causing "Grassy-shoot" of sugarcane was transmitted to Napier grass (*Pennisetum purpureum*) and *Phaseolus vulgaris* both by mechanical inoculation and through the vector, *Longiunguis sacchari*. *L. pseudosacchari* and *Aphis maidis* were found to be additional vectors of the virus. The virus, causing "Foorkey" disease of large cardamom was successfully transmitted to two wild *Amomum* spp. and small cardamom by means of the viruliferous aphids (*Pentalonia nigronervosa*). Sesamum phyllody virus was transmitted to *Trifolium alexandrinum, T. lappacerum, Medicago scutellate, Melilotus indica, phlox drummondii and petunia violacea* through *Deltocephalus* sp.

Four viruses were isolated from mosaic-affected brinjal plants. Gooseberry mosaic virus was found to be a strain of tobacco mosaic virus and was transmitted by hands contaminated with chewing tobacco. Sannhemp mosaic virus was found to be transmitted by root inoculation with the infective juice. "Chirke" disease of large cardamom was transmitted to arrowroot and wheat.

In the varietal resistance tests, *Gossypium barbadense, G. raimondii G. anomalum, G. stocksii and G. davidsonii* proved to be immune to the 'Small leaf' disease of cotton. *Musa balbisiana* showed complete immunity to Banana mosaic virus. The immunity of Portugese *Abelmoschus manihot* and *A. crinitus* to yellow-vein mosaic virus was confirmed. The chilli varieties, Puri Red, Puri Orange, Cuttack Red Erect, Kondevarum, and the cross (Puri Red × N.P. 46A) proved to be immune to the chilli mosaic virus.

The virus-vector relationship was studied with regard to 'Foorkey' disease of large cardamom and the 'Grassy shoot' of sugarcane. Even a single alate female of the banana aphid, *Pentalonia nigronervosa*, was able to transmit the "Foorkey' disease. The aphid *Longiunguis sacchari* was able to acquire the virus from 'Grassy shoot'-affected canes in 5 minutes and transmit it to healthy cane plants in ten minutes.

Systematic Mycology

Alternaria choirandhi and four new hosts for the genus *Colletorichum* were recorded for the first time in the country. Also, two new genera (*Coniosporium* Link and *Diploplenodomma* Died) and seven new records of Hyphomycetes were made. Regarding Ervsiphales, one species and eight hosts were found to be new to India. Taxonomic studies on miscellaneous Indian Fungi were also continued which resulted in establishing eight species new to science and thirty new records for India.

Division of Horticulture

Pomology

(i) *Survey and collection of superior germplasm in tree fruits.*— Survey work in important commercial fruits, like mango, citrus, guava and grapes, has been put underway.

A collection of varieties of grapes from several parts of the world, including New Zealand, Yugoslavia, Italy, Switzerland and the U.S.A., has been built up for evaluation; the total number of grape varieties now stands at 152.

(ii) *Propagation studies.* Among the various methods of propagation of phalsa tried, inarching and ring budding gave 100 and 65 per cent. success, respectively. This is the first time that such propagation methods have succeeded in India and constitute a definite improvement over the prevalent method of propagation from seed.

(iii) *Application of growth regulators to fruit crops,*

(a) *Strawberry.*—Trials, using gibberellic acid and para-chlorophenoxy-acetic acid, have shown some promising results. The former, at 10 p.p.m., seems to increase the length of pedicel, number of flowers and the cumulative yield, whereas the latter chemical (also at 10 p.p.m.) appeared to accelerate fruit maturity and ripening.

(b) *Grapes.*—Gibberellic acid, sprayed in aqueous solution (10 p.p.m.) on the seedless grape variety 'Pusa Seedless', increased the fruit set by 44 per cent. as compared to the control; spraying at 50 p.p.m. appeared to markedly increase the size of bunches by 223 per cent., without adversely affecting the fruit quality.

(c) *Guava.*—Sprays of maleic hydrazide (1500 and 2500 p.p.m.), 2. 4. dichlorophenoxyacetic acid (100 to 150 p.p.m.) and sodium azide (1500, 2500 p.p.m.) were effective in thinning the rainy season crop, which is generally of poor quality. This appears to be an easy way of thinning out an unwanted blossom.

(iv) *Fruit tree bneedum*

(a) *Grapes.*—Of the 152 varieties of grapes collected from within the country and abroad, 17 varieties came to fruiting during this year and were studied in detail. The varieties Kandhari, Bhokri, Alamwick, Hur and Fakhri ripened by the first week of June and the varieties Pusa Seedless, Black Muscat, Black Prince, Gros Colman, Habshi, Bharat Early and Black Hamburg ripened by the 15th of June, indicating the utility of these varieties under Delhi conditions by fruiting prior to the onset of monsoon.

The seedless variety, 'Pusa Seedless', appeared to be a particularly good variety, bearing under Delhi conditions a medium to heavy crop when trained on pergola. The variety promises to be worthy of recommending for general distribution.

(b) *Citrus.*—An interesting bud mutant in Foster (Pink) grapefruit has been observed and may be commercially important. On one tree of the grapefruit variety Foster, which is highly

seeded, all the fruits, while resembling the parent variety in all other characters, were nearly seedless. The number of seeds per fruit in the new sport ranged from 4 to 7, as against 44 to 67 in Foster and 3 to 8 in Marsh Seedless.

(v) *Cytological and cytogenetical studies.*—The chromosome number in the pomegranate variety, "Double Flower", was found to be 2n=18, while in other varieties, such as Dholka, Muscat White, Kandhari and Patiala, the number was 2n=16.

Vegetables

(i) *Survey, collection and evaluation of indigenous vegetables.*—A collection of about 440 varieties of indigenous vegetables was made.

(ii) *Sex-ratio in cucurbits.*—A study of the sex-ratio in six varieties each of ridge gourd (*Luffa acutangula*) and cucumber (*Cucumis sativus*) was made with a view to selecting varieties with high female-to-male-flower ratio. I.C.3222 and Pusa Nasdar of ridgegourd, and Khira Poona and Straight Eight of cucumber, recorded high female-to-male-flower ratios.

(iii) *Chemical induction of male sterility and suppression of male flowers in cucurbits.*—The study was initiated in the cucumber variety, "Straight Eight". Four chemicals at different concentrations were sprayed on the seedlings of cucumber. Highest pollen sterility was observed with maleic hydrazide at 800 p.p.m., followed by naphthaleneactic acid at 200 p.p.m. There was no abnormality in the morphology of the petals or the fertility of the female parts as a result of the sprays. Suppression of male flowers and forcing up of the female-to-male-flower ratio were noticed in a cucumber variety sprayed with maleic hydrazide (200, 400 and 600 p.p.m.), naphthaleneacetic acid (100 and 200 p.p.m.), and indoleacetic acid (200 p.p.m.).

(iv) *Study on the effect of growth regulator sprays on the destruction of interruption of apical dominance*—A preliminary study, using maleic hydrazide, was conducted on the cowpea variety "Pusa Barsati". A 200 p.p.m. spray increased the total yield per plant by about 60 per cent. over the control.

(v) *Effect of plant regulator sprays on fruit set.*—The effect of six different plant regulator sprays, at varying concentrations, was studied on two varieties of tomato, sioux and Pusa Ruby. Varietal differences in the response to the plant regulators were noticeable; increased fruit setting was also observed.

DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Agricultural Chemistry

In view of the proposed manufacture of new fertilizers in the country, the relative performance of urea, ammonium nitrate, ammonium sulphate, nitrate, ammonium chloride and ammonium sulphate was tested in pots and in the field on wheat and potato. No appreciable differences in their performance were observed.

A simple method has been developed to prepare dried manure from blood collected from slaughter houses by clotting the blood with superphosphate and subsequent drying.

Further improvements were made in the design of the cow-dung gas plant for effective utilization of organic waste, along with dung, for gas production. Significantly better illumination of gas lamps was obtained by allowing the gas to pass through a trap containing a small quantity of petrol or solvent oil.

Physical Chemistry.—

The colloidal behaviour of soils has shown that the limit for the degree of sodiumisation needed to cause the dispersive characteristics of alkali soils was different for different soils. However, the soil solution in equilibrium with those soils at this limit had nearly the same characteristic value of its sodium absorption activity ratio.

X-ray diffraction studies were conducted for investigating into the mineralogical composition of clays from different Indian soils and to find out the inter-action of clay-minerals with organic compounds. The X-ray diffraction patterns of montmorillonite and illite with glycerol indicate a definite interaction of these minerals with glycerol.

Organic Chemistry.—

The pilot plant investigations for the production of terpene ethers and alcohols—synthetic pine oil, as reported last year have been successfully completed. Preliminary reports received from various users have been encouraging. Indian turpentine oil gave yields of 30—32 of terpene ethers and alcohols which resemble natural pine oil in chemical composition and physical characteristics. The patented process has been licensed out to two firms for commercial development.

Physics.—

It has been found that electrolytically pure copper rods can be used instead of spectroscopically pure copper for the estimation of boron and manganese in soils and plants. This not only reduces the cost of the electrodes but also saves on foreign exchange.

Biochemistry.—

Foliar application of urea to the barley crop resulted in increased yield of grain.

An activator for the growth of *Lactobacillus leichmannii* has been found in tomato juice. It is non-dialysable, heat stable, precipitated by acetone, ammonium sulphate and salts of heavy metals. It is destroyed by ashing, while ultra-violet irradiation has no effect. Experiments on the respiratory mechanism of this organism have shown that it does not oxidise any amino-acid, while sodium pyruvate, lactic acid and glucose are easily oxidised.

Microbiology.—

Preliminary experiments indicated that the addition of phosphobacteria to the soil increases the yield of maize as much as is done by the application of superphosphate at 60 lb. P_2O_5 per acre.

Cobalt has been found to stimulate nitrogen fixation in bacteria; the micro-element itself gets incorporated in the body of bacteria.

The wild legume *Aeschynomene aspera*, widely available in the rice-growing tracts of Bengal, was found to nitrify as rapidly and enriched the organic nitrogen content of the soil to the same extent, as sannhemp.

Soil Testing.—

Fifteen Soil Testing Laboratories started functioning during the year. Under this project, a mobile van was pressed into operation in the Punjab and in parts of Bombay State for carrying out on-the-spot analysis of soil; 30,000 samples of soils were analysed and fertilizer recommendations were made to farmers on the basis of the analysis.

On the basis of soil tests it has been observed that 70·1 per cent. of the Indian soils analysed are low in phosphorus content, 20·1 per cent. medium and only 9·8 per cent. high in phosphorus. Available potash is low in 27:6 per cent. of the soils 35·3 per cent. medium and 37:1 per cent. high. In carbon and available nitrogen status, about 63 per cent. are low, 20 per cent. medium and 17 per cent. high. About 1·7 per cent. of the soils have soluble salts critical for crop growth, while 1 per cent. are alkali soils requiring reclamation.

Radio-tracer Investigations.—

Tagged superphosphate was applied at different doses to wheat and paddy grown in green house on different soils collected from all over the country. The utilization of the applied fertilizer varied from 8 to 16 per cent. in the case wheat, from 2 to 9 per cent. in early paddy, and from 2 to 20 per cent. in late paddy.

A method for radio-autographic study of movement of phosphorus in soil column was developed.

In a study on the comparative efficiency of various phosphatic fertilizers, super, monocalcium, dicalcium, meta, mono-ammonium, diammonium and amoniated super-phosphates were compared. Wheat was the test crop grown on alluvial and black cotton soils. Mono-ammonium phosphate was more efficient than the other carriers tested. Superphosphate was the next in order.

Division of Agricultural Engineering

Evolution of superior implements.—

A bullock-operated seed-drill was designed and fabricated and successfully tested for sowing wheat, barley and maize. On the basis of these results a four-row drill was manufactured and is awaiting field test. Development of another type of four-row seed-drill with fluted roller type seed metering mechanism has also been completed. The machine is balanced for operation on four furrow-openers. The seed metering machine can be put out of action by a simple dog clutch mechanism which is operated through a handle provided within the easy reach of the operator.

A bullock-drawn fertilizer placement-*cum*-sowing machine has been designed and developed. The machine has separate chambers for storing seeds and fertilizer.

A bullock-drawn scraper—leveller blade has been fabricated on the basis of a design received from the T.C.M. This is a well constructed wooden blade provided with a steel cutting blade and a control handle to alter the angle of attack of the cutting blade. The operator can cut earth from high spots, transport it and dump the load in depression at will.

Accurate control on the quantity of water is essential for efficiency in irrigation and conservation of irrigation water. A ventury flume, with 6″ throat, has been fabricated to measure small water flows.

Application for use with cow-dung gas.—

The economic possibilities of the cow-dung gas plant under Indian conditions in helping farmers to attain higher living standards are considerable. So far the only devices available are the ones designed for coal gas or town gas. The performance of these devices, particularly the ones used for illumination, leave much to be desired in performance. In this connection, a simple village model *choola* has been evolved and fabricated and work is in progress on the evolution of a suitable incandescent lamp.

All-India Soil and Land Use Survey

The All-India Soil Survey Scheme of the Indian Agricultural Research Institute and the Land Use Survey and Planning Organisation of the Soil Conservation Board have been integrated from 1st March, 1958, under the "All-India Soil and Land Use Survey" at this Institute. Thus, all the soil surveys are now centralized under one agency. The progress of work of each region is summarised briefly.

(i) *Alluvial Soil Region,—Delhi.*—The soil survey and classification of Banga N.E.S. Block has been completed. Soil maps have been prepared for the Nawanshahr and Banga N.E.S. Block comprising a total area of 1,92,000 acres. A reconnaissance survey of Sohawal N.E.S. Block, Distt. Satna, M.P. was completed. The soils covering a total area of 1,31,000 acres have been classified and mapped. Soil conservation and land use survey has been taken up in the Bhakra Nangal catchment areas.

(ii) *Black Soil Region,—Nagpur.*—A reconnaissance soil survey of the Nasik district, commenced in 1957, has been continued and a total area of 22,37,000 acres has been covered. A soil conservation and land use survey of Hirakud catchment area was taken up.

(iii) *Red and Laterite Soil Region-I.—Calcutta.*- In continuation of the soil survey carried out in Asansol Sub-division in West Bengal, reconnaissance soil survey of about 1,18,000 acres has been completed. The laterite soil areas, covering an area of 70,000 acres of Muruda Police Station in Orissa, have also been surveyed, classified and mapped. Soil conservation and land use survey has been taken up in the irrigated areas commanded by the Damodar Valley irrigation systems in the Kanksa Police Station of West Bengal. An area of 15,000 acres has been surveyed in detail and the soil maps are under preparation. Soil conservation survey has been started of the watershed areas of the Machkund river valley project.

(iv) *Red and Laterite Soil Region-II.—Bangalore.*—A rapid reconnaissance soil survey of Vayalpad in Chittur district and Rayachoti in Cuddappah district has been completed. Soil maps have been prepared covering a total area of about 7·25 lakh acres. In the Shimoga district of Mysore, soil surveys have been carried out in Honnali, Shikaripur and Scrab taluks. A total area of 2·1 lakh acres has been classified and necessary soil maps have been prepared.

3. GENERAL

(a) GAZETTED STAFF

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Agronomist . . . . . Shri A. R. Khan, M.Sc. (Ag.), M.S. (Wisconsin).

Agronomist . . . . . Dr. J. N. Sharma, M.Sc. (Ag.), Ph.D.

Asstt. Agronomist . . . . Shri J. J. Chandnani, M.Sc. (Ag.).

Asstt. Agronomist . . . . Dr. H. S. Mann, M.Sc., Ph.D. (Kansas).

Asstt. Agronomist . . . . Shri S. S. Bains, B.Sc. (Ag.), Assoc. I.A.R.I.

Asstt. Agronomist (Instruction) . Shri K. P. Misra, M.Sc., 1-3-57 to 30-5-57.

Asstt. Agronomist . . . . Dr. K. S. Yawalkar, B.Sc. (Ag.), Ph.D. (Minn) Assoc. I.A.R.I.,—upto 4-2-58.

STATISTICS SECTION

Head of the Section . . . . Dr. P. N. Saxena, M.A., Ph.D.

Asstt. Statistician . . . . Shri A. G. Kavitkar, B.Sc., Assoc. I.A.R.I.

AGRICULTURAL ECONOMICS SECTION

Head of the Section . . . Dr. T. P. S. Chowdhury, B.Ag., M.Sc., Ph.D.(Wis.) —from 1-3-58.

AGRICULTURAL SUB-STATION, KARNAL

Asstt. Agronomist . . . . Shri R. S. Gupta, B.Sc., Assoc. I.A.R.I.

PROJECT FOR IRRIGATION INVESTIGATION

Agronomist . . . . . Dr. Mukhtar Singh, M.Sc. (Ag.), Ph.D. (Edin.).

Asst. Agronomist . . . . Shri R. T. Gandhi, B.Sc. (Ag.), Assoc. I.A.R.I.,—from 27-12-57.

PROJECT FOR SETTING UP P. G. COURSE IN AGRICULTURAL EXTENSION

Agricultural Development Officer . Shri S. R. Oberoi, B.Sc. (Ag.), Assoc. I.A.R.I.—on leave.

SCHEME FOR INVESTIGATION ON WEED CONTROL

Agronomist . . . . . Dr. R. D. Verma, B.Sc. (Ag.), B.Sc. Hons. (Edin.) M.S. (Iowa), Ph.D. (Edin.)

Asstt. Agronomist . . . . Dr. C. H. Pathak, M.Sc., Ph. D.,—11-10-57 to 1-4-58.

PROJECT FOR PLANT TISSUE AND SPRAY FERTILIZER INVESTIGATION SCHEME

Agronomist . . . . . Dr. K. S. Yawalkar, B.Sc. (Ag.), Ph.D. (Minn.), Assoc. I.A.R.I.,— from 4-2-58.

DIVISION OF BOTANY

Head of the Division	Dr. S. M. Sikka, M.Sc., Ph.D. (Lond.), Assoc. I.A.R.I., —upto 1-6-58.
Plant Physiologist	Dr. R. D. Asana, M.Sc., Ph.D. (Lond.), D.I.C.
Geneticist	Dr. A. B. Joshi, M.Sc., Ph.D. (Cantab.), Assoc. I.A.R.I.
Cytogeneticist	Dr. M. S. Swaminathan, B. Sc., B. Sc. (Ag.), Ph.D. (Cantab.), Assoc. I.A.R.I.
Systematic Botanist	Dr. D. Chatterjee, M.Sc., Ph.D. (Lond.), —on other duty.
Asstt. Plant Physiologist	Shri T. J. Malkani, M.Sc.
Asstt. Cytogeneticist	Shri A. T. Natarajan, M. Sc., Assoc. I.A.R.I.,—from 11-12-58.
Asstt. Geneticist	Shri Amir Singh, M.Sc. (Ag.),—from 26-4-58.
Asstt. Geneticist	Shri M. Ahluwalia, B.Sc. Hons., Assoc. I.A.R.I.—from 26-4-58.
Asstt. Geneticist	Shri R. K. Mehta, B.Sc. (Ag.), Assoc. I.A.R.I.—from 26-4-58.
Asstt Agrostologist	Shri P. M. Dhabadgao, M.Sc.,—on other duty. Shri B. D. Patil, B.Sc. (Ag.) (Hons.),—from 5-4-58.

Botanical Sub-Station, Pusa (Bihar)

Superintendent	Shri M. D. Nandkeolyar, M.Sc.

Central Vegetable Breeding Sub-station, Katrain

Vegetable Specialist	Shri H. B. Singh, M.Sc., Assoc. I.A.R.I.—upto 30-11-58.

Co-ordinated Wheat Rust Control Scheme

Delhi Centre

Wheat Breeder	Dr. G. S. Murthy, M.Sc., Ph.D. (Minn.), Assoc. I.A.R.I.
Asstt. Wheat Breeder	Shri M. V. Rao, M.Sc.—from 28-11-58.
Asstt. Statistician	Shri Daljit Singh, B.Sc., Assoc. I.A.R.I.

Simla Centre

Asstt. Wheat Breeder	Dr. S. P. Kohli, M.Sc., Ph.D. (Cornell)—on other duty. Dr. S. Kedharnath, M.A., M.Sc., Ph.D. (Wisc.),—from 3-12-57.

Wellington Centre

Asstt. Wheat Breeder	Shri V. K. Srinivasan, M.Sc.

Indore Centre

Asstt. Wheat Breeder	Shri V. S. Mathur, M.Sc. (Ag.).

Pusa Centre

Asstt. Wheat Breeder	Shri Y. M. Upadhaya, B.Sc., Assoc. I.A.R.I.

Plant Introduction and Exploration Organisation

Delhi Centre

Plant Introduction Officer	Shri H. B. Singh, M.Sc., Assoc. I.A.R.I.,—from 30-11-58.
Asstt. Botanist	Shri S. P. Mittal, M.Sc., Assoc. I.A.R.I.

SCHEME FOR SETTING UP OF A SEED TESTING STATION

Seed Testing Officer . . . . Dr. N. L. Dhawan, M.Sc., Ph.D. (Minn.),—upto 5-7-57.

SCHEME FOR USE OF RADIO-ACTIVE ISOTOPES IN CYTOGENETIC STUDIES

Asstt. Cytogeneticist . . . Dr. H. K. Jain, B.Sc. (Hons.), Ph.D. (Wales), Assoc. I.A.R.I.

SCHEME FOR ESTABLISHMENT OF UNIT FOR EMBRYO-CULTURE

Asstt. Cytogeneticist . . . Shri S. Ramanujam, B.Sc. (Hons.), Assoc. I.A.R.I.

SCHEME FOR CYTOLOGICAL STUDIES IN OILSEEDS

Asstt. Cytogeneticist . . . Shri S. S. Rajan, M.Sc.

SCHEME FOR IMPROVEMENT OF ESSENTIAL OIL YIELDING PLANTS

Delhi Centre

Asstt. Botanist . . . . . Shri B. S. Joshi, B.Sc. (Ag.), Assoc. I.A.R.I.

Chemist . . . . . Dr. G. S. Krishna Rao, M.Sc., Ph.D., Assoc. I.A.R.I.—upto 1-6-58.

Pusa Centre

Asstt. Botanist . . . . . Shri M. G. Joshi, B.Sc. (Ag.), Assoc. I.A.R.I

Katrain Centre

Asstt. Botanist . . . . . Shri P. M. Bhagchandani, B.Sc. (Ag.), Assoc. I.A.R.I.

Jamnagar Centre

Asstt. Botanist . . . . . Shri L. M. Jeswani, B.Sc. (Ag.), Assoc. I.A.R.I.

ADDITIONAL STAFF FOR THE PLANT BREEDING AND GENETICS SECTION

Geneticist . . . . . Dr. S. P. Kohli, M.Sc., Ph.D. (Cornell).

Geneticist . . . . . Shri R. B. Deshpande, M.Sc., Assoc. I.A.R.I.

Asstt. Geneticist . . . . . Shri M. W. Hardas, M.Sc., Assoc. I.A.R.I.

Asstt. Geneticist . . . . . Dr. Vishnu Swarup, M.Sc., Ph.D. (Kansas), Assoc. I.A.R.I.

Asstt. Geneticist . . . . . Shri R. K. Mehta, B.Sc. (Ag.), Assoc. I.A.R.I.—11-3-57 to 25-4-58.

SCHEME FOR THE STUDY OF GENETICS AND VARIABILITY IN ALGAE

Assistant Botanist . . . . . Shri G.S. Venkataraman, M.Sc.

SCHEME FOR STUDY OF MILLING, BAKING, AND CHAPATI—MAKING QUALITY IN WHEAT

Asst. Plant Physiologist . . . Dr. A. Austin, M.Sc. (Ag.), M.Sc. (Lond.), D.Sc. (Utrecht)—from 6-11-57.

CO-ORDINATED MAIZE BREEDING SCHEME

Maize Breeder . . . . . Dr. N. L. Dhawan, M.Sc., Ph.D. (Minn.), Assoc. I.A.R.I.—from 6-7-57.

Asstt. Maize Breeder . . . Shri Amir Singh, M.Sc. (Ag.),—upto 25-4-58.

CO-ORDINATED SCHEME FOR PRE-SOAKING SEEDS IN NUTRIENT SALTS

Asstt. Plant Physiologist . . . Shri S. P. Singh, B.Sc. (Ag.), Assoc. I.A.R.I.—from 17-1-57.

CO-ORDINATED SCHEME FOR CITRUS DIE-BACK DISEASE

Asstt. Plant Physiologist . . . Shri V. S. Mani, M.Sc.

DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Head of the Division	Dr. S. P. Raychaudhuri, M.S.C.,Ph.D. (Lond.), D.Sc. (Cal & Lond.)—upto 1-3-58. (on other duty).
	Dr. R. V. Tamhane, B.Ag., Ph.D. (Lond.),—from 19-6-58.
Biochemist	Dr. N. B. Das, D. Phil.
Organic Chemist	Dr. K. C. Gulati, M.Sc. (Hons.), Ph.D.
Physical Chemist	Dr. B. Ramamoorthy, M.Sc. D. Phil., Assoc. I.A.R.I.
Soil Microbiologist	Dr. W. V. B. Sundara Rao, M.Sc. (Hons.), Ph.D. Assoc. I.A.R.I.,—from 7-9-57.
Soil Scientist	Dr. T. D. Biswas, M.Sc., D. Phil (Cal.)—from 7-4-58
Experimental Physicist	Dr. Y. V. Kathavate, M.Sc., Ph.D.
Asstt. Agricultural Chemist	Shri M. A. Idnani, B.Sc., Assoc. I.A.R.I.—upto 13-5-58.
Asstt. Soil Microbiologist	Dr. A. Sen, M.Sc., Ph.D., Assoc. I.A.R.I.
Asstt. Soil Physicist	Dr. B. T. Mulwani, B.Ag., M.Sc., Ph.D. (Lond.), D.I.C.
Asstt. Soil Survey Officer	Dr. T. D. Biswas, M.Sc., D. Phil (Cal.)—upto 6-4-58.
Asstt. Soil Survey Officer	Shri R. S. Murthy, M.Sc. (Ag.).
Asstt. Organic Chemist	Dr. A. R. S. Kartha, M.Sc., Ph.D.
Asstt. Soil Chemist	Shri A. B. Ghosh, M.Sc.
Asstt. Physical Chemist	Dr. S. C. Das, M.Sc., D. Phil. (Cal.).
Asstt. Biochemist	Dr. B. M. Lal, M.Sc., Ph.D.

Scheme for determination of Soil Fertility and Fertilizer Use

Soil Scientist	Dr. N. P. Dutta, D.Sc., A.R.I.C.
Asstt. Soil Chemist	Dr. B. V. Subbiah, M.Sc., Ph.D. (Bombay).

Scheme for Working Electron Microscope

Asstt. Physicist	Shri S. C. Mehta, M.Sc.

Scheme for Studies on the Chemical Composition and Nutritive Value of Wheat

Asstt. Biochemist	Dr. B. M. Lal, M.Sc., Ph.D.—upto 31-3-57.

Scheme for Examining the Behaviour of Certain Additional Chemical Fertilizers under Storage Conditions

Fertilizer Technologist	Shri M. A. Idnani, B.Sc., Assoc. I.A.R.I.—from 14-5-58.

Unit of Physics

Senior Physicist	Dr. C. Dakshinamurti, D.Sc. (Banaras), Ph.D. (Lond.), F. Inst. P. (Lond.).

Scheme for Expanded Soil Testing Service

Delhi Centre

Special Officer	Dr. R. V. Tamhane, B.Ag., Ph.D. (Lond).—upto 18-6-58.
Asstt. Soil Chemist	Shri P. K. Oomen, M.Sc. (Tech.)

Nagpur Centre

Asstt. Soil Chemist	Shri V. K. Misra, B.Sc., A.I.I.S.T., Assoc. I.A.R.I.

Calcutta Centre

Asstt. Soil Chemist	Shri B. B. Rudra, M.Sc., Assoc. I.A.R.I.

Poona Centre

Asstt. Soil Chemist	Shri N. G. Perur, M.Sc.—upto 26-8-57.

SCHEME FOR EXPANDED SOIL TESTING SERVICE—(*contd.*)

Coimbatore Centre

Asstt. Soil Chemist . . . . Shri T. R. Srinivasan, B.Sc., Assoc. I.A.R.I.

Ludhiana Centre

Asstt. Soil Chemist . . . Shri Bhagvan Das, M.Sc.

Sabour Centre

Asstt. Soil Chemist . . . Dr. N. R. Datta Biswas, M.Sc., Ph.D.

Sambalpur Centre

Asstt. Soil Chemist . . . Shri U. C. Padhi, B.Sc. (Hons.), Assoc. I.A.R.I.

Hyderabad Centre

Asstt. Soil Chemist . . . Shri P. M. Joshi, B.Sc., Assoc. I.A.R.I.

Bangalore Centre

Asstt. Soil Chemist . . . . Shri H. G. Gopala Rao, M.Sc.

Nabha Centre

Asstt. Soil Chemist . . . . Shri K. L. Nayar, M.Sc. (Ag.)—from 1-9-57.

Trivandrum Centre

Asstt. Soil Chemist . . . . Shri H. Sankara Subrahmoney, M.Sc.

Gwalior Centre

Asstt. Soil Chemist . . . Shri Y. P. Bali, B.Sc. Ag. (Hons.), Assoc. I.A.R.I.

Simla Centre

Asstt. Soil Chemist . . . . Shri P. C. Thakur, B.Sc., Assoc. I.A.R.I.

Balehonur Centre

Asstt. Soil Chemist . . . Shri P. K. Mathew, M.Sc.—from 14-6-58.

Baptala Centre

Asstt. Soil Chemist . . . . Shri G. R. Rao, M.Sc.—from 13-7-58.

Jodhpur Centre

Asstt. Soil Chemist . . . . Shri S. P. Seth, M.Sc. (Hons.) —from 10-6-58.

Hazaribagh Centre

Asstt. Soil Chemist . . . . Shri R. K. Asthana, M.Sc.,—from 14-6-58.

Agartala Centre

Asstt. Soil Chemist . . . . Shri A. N. Sen, M.Sc. (Hons.)—from 10-6-58.

DIVISION OF ENTOMOLOGY

Head of the Division . . . . Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C. F.R.E.S., F.E.S.I.

Systematic Entomologist . . . Dr. M. G. Ramdas Menon, M.Sc., Ph.D. (Bom.), F.R.E.S, F.E.S.I.

Parasitologist . . . . . Vacant.

Toxicologist . . . . . Dr. S. Pradhan, Ph.D. (Lond.), D.Sc , F.R.E.S, F.E.S.I.

Asstt. Systematic Entomologist . Dr. S. M. Chatterjee, M.Sc., Ph.D. (Agra), Assoc. I.A.R.I., F.R.E.S., F.E.S.I, F.A.Z.

Asstt. Ecologist . . . . Shri H. N. Batra, B.Sc. (Ag.), Assoc. I.A.R.I.—upto 29-4-58.

SCHEME REGARDING RESEARCH ON INSECT PHYSIOLOGY

Insect Physiologist . . Dr. N. C. Pant, M.Sc. (Ag.), Ph.D. (Lond.), D.I.C.

TERMITE SCHEME

Asstt. Entomologist . . . Dr. H. J. Bhambani, B.Sc., Ph.D. (Lond.) Assoc. I.A.R.I.

SCHEME FOR BIOLOGICAL TESTING AND CERTIFICATION OF INSECTICIDE

Asstt. Entomologist . . . Shri M. G. Motwani, B.Sc., Assoc. I.A.R.I.

SCHEME FOR ESTABLISHING A UNIT FOR STORAGE PEST ECOLOGY

Asstt. Entomologist . . . Shri P. B. Mukherjee, B.Sc., Assoc. I.A.R.I.

SCHEME FOR SURVEY OF BENEFICIAL PARASITES OF PESTS OF AGRICULTURAL CROPS

Asstt. Entomologist . . . Dr. B. R. Subba Rao, B.Sc., Ph.D., Assoc. I.A.R.I.

SCHEME FOR ENTOMOLOGICAL INVESTIGATION WITH THE HELP OF RADIO-ACTIVE ISOTOPES

Entomologist . . . . . Dr. Rattan Lal, M.Sc., Ph.D., Assoc. I.A.R.I.

SCHEME FOR SETTING UP OF SEED TESTING STATION

Entomologist . . . . . Shri H. N. Batra, B.Sc. (Ag.), Assoc. I.A.R.I.

Dr. B. K. Srivastava, M.Sc. (Ag.), Ph.D. (Kansas)—upto 19-12-57.

LOCUST TOXICITY SCHEME

Asstt. Toxicologist . . . . Dr. P. D. Srivastava, M.Sc., D. Phil. (Allahabad),—from 8-2-58.

SCHEME FOR RESEARCH ON INDIAN HONEY BEE, AT B.S.S, PUSA

Asstt. Entomologist . . . Shri Pritam Lal Sharma, M.Sc. (Ag.).

SCHEME FOR EXPLORATION OF TOXICITY HAZARDS

Asstt. Entomologist . . . Shri Y. P. Beri, M.Sc.

Asstt. Chemist . . . . . Shri R. S. Diwan, M.Sc. (Tech.).

DIVISION OF AGRICULTURAL ENGINEERING

Head of the Division . . . Shri E.K.G.Rao., B.Sc (Eng),. A.M.I.E.(Ind) M.M.E.A. from 18. 12.59

Assistant Engineer . . . . Shri J. S. Manku, B.Sc. (Engg.), A.M.I.E., A.M.I. Mech. E. A.M.I. Prod. E.

Assistant Engineer . . . . Shri R. P. Singh, B.Sc. (Agric. Engg.), M.Sc. (Ag.).

Assistant Engineer . . . . Shri R. S. Kahlon, B.Sc. (Ag.), B.Sc. (Engg.).

SURVEY OF INDIGENOUS AGRICULTURAL IMPLEMENTS

Mechanical Engineer . . . Shri J. R. Badola, B.Sc. (Agric. Engg.).

DIVISION OF HORTICULTURE

Head of the Division . . . Dr. S. Krishnamurthi, B.Sc. (Ag.), Ph.D. (Calif.)—from 1-3-58.

Horticulturist . . . . . Dr. G. S. Randhawa, M.Sc., M.S.A. (Toronto). Ph.D. (Mich.)

Vegetable Breeder . . . . Dr. B. Choudhury, Ph.D. (Melbourne), F.R.H.S.

Asstt. Horticulturist . . . Dr. Jagpal Singh, M.Sc., Ph.D. (Mich.).

Garden Superintendent . . . Shri Romesh Chandra, B.Sc. (Ag.).

DIVISION OF MYCOLOGY AND PLANT PATHOLOGY

Head of the Division . . . Dr. R. S. Vasudeva, D.Sc. (Lond.), Ph.D. (Lond.), D.I.C., F.N.I.

Systematic Mycologist . . . Dr. B. L. Chona, B.Sc., Ph.D. (Lond.).

Asstt. Plant Pathologist . . . Dr. M. L. Gattani, M.Sc., Ph.D. (Minn.)—on leave.
Dr. Kishan Singh, M.Sc., Ph.D.
Asstt. Virus Pathologist . . . Shri H. S. Sahambi, M.Sc.
Asstt. Plant Bacteriologist . . Vacant.
Herbarium Keeper . . . . Shri J. N. Kapoor, M.Sc., Assoc. I.A.R.I.

CO-ORDINATED WHEAT RUST CONTROL SCHEME

Delhi Centre

Mycologist . . . . . Dr. R. Prasada, D.Sc.

Simla Centre

Asstt. Mycologist . . . . Shri D. P. Misra, M.Sc.—upto 31-4-58.
Dr. S. Singh, M.Sc. (Ag.), Ph.D. (Minn.)—from 1-5-58
Asstt. Mycologist . . . . Shri V. C. Lele, M.Sc. (Ag.).
Asstt. Mycologist . . . . Dr. G. Swarup, M.Sc., M.S., Ph.D., Assoc. I.A.R.I-upto 10-2-58.
Dr. M. M. Payak, M.Sc. (Ag.), Ph.D.—from 10-2-58.

Wellington Centre

Asstt. Mycologist . . . . Shri L. M. Joshi, M.Sc.

CO-ORDINATED PLANT VIRUS RESEARCH SCHEME

Simla Centre

Asstt. Virus Pathologist . . . Shri R. N. Azad, B.Sc. (Ag.), Assoc. I.A.R.I.

Poona Centre

Virus Entomologist . . . Shri P. M. Verma, M.Sc.
Virus Pathologist . . . Dr. S. P. Capoor, M.Sc., Ph.D.

KALIMPONG CENTRE (EASTERN ZONE)

Virus Pathologist . . . . Dr. S. P. Raychaudhuri, M.Sc., D. Phil. (Cal.), Assoc. I.A.R.I.
Virus Entomologist . . . . Shri S. N. Chatterjee, M.Sc., Assoc. I.A.R.I.

SCHEME FOR CO-ORDINATED PLANT VIRUS DISEASE

Delhi Centre

Asstt. Virus Pathologist . . . Shri T. K. Nariani, B.Sc., Assoc. I.A.R.I.

Simla Centre

Asstt. Virus Pathologist . . . Shri M. L. Seth, M.Sc.—upto 23 5-58.
Dr. B. B. Nagiach, M.Sc., Ph.D. (Illinois)— from 24-5-58.

SCHEME FOR THE USE OF ATOMIC ENERGY IN PLANT PATHOLOGICAL RESEARCH

Asstt. Plant Pathologist . . . Shri B. S. Bajaj, M.Sc.

SCHEME FOR THE STUDY OF BACTERIAL PLANT PATHOGENS

Plant Bacteriologist . . . . Dr. M. K. Hingorani, M.Sc., Ph.D. (Minn.), Assoc. I.A.R.I.

SCHEME FOR SETTING UP OF SEED TESTING STATION

Plant Pathologist . . . Dr. D. Suryanarayana, M.Sc., D. Sc. (Agra).

SCHEME FOR THE APPRAISAL OF LOSSES DUE TO PLANT DISEASE

Mycologist . . . . . Shri B. L. Munjal, M.Sc.

ALL INDIA SOIL AND LAND USE SURVEY

Delhi Centre

Chief Soil Survey Officer . . Dr. S. P. Raychaudhuri, M.Sc. Ph.D. (Lond.), DSc. (Cal. & Lond.), F.R.I.C., F.N.I.—from 1-3-58.

Soil Correlator . . . . Dr. K. V. S. Satyanarayana, B.Sc. (Ag.), Ph.D., Assoc. I.A.R.I.

Stores Officer . . . . . Shri C. S. Jain, B.Com., LL.B.

Bangalore Centre

Soil Correlator . . . . Dr. S. V. Govindarajan, B.Sc. (Hons.), Ph.D. (Lond.), D.I.C., A.R.I.C.

Nagpur Centre

Soil Correlator . . . . Dr. B. B. Roy, M.Sc., Ph.D. (Lond.).

Calcutta Centre

Soil Correlator . . . . Shri S. Digar, M.Sc., Dip. Agri. (Cantab).

SCHEME FOR COLLECTION AND COLLATION OF SOIL SURVEY DATA IN INDIA

Delhi Centre

Soil Survey Officer . . . Shri S. P. Gupta, B.Sc. (Hons.), Assoc. I.A.R.I.—from 24-6-58.

C. W. P. C. Centre

Soil Survey Officer . . . Shri P. K. Thomas, B.Sc., Assoc. I.A.R.I.—from 28-4-58

CENTRAL COLLEGE OF AGRICULTURE

Principal . . . . . Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C. F.R.E.S., F.E.S.I.

Lecturer in Agriculture . . . Shri Diwan Singh, M.Sc. (Ag.).

Lecturer in Chemistry . . . Dr. W. V. B. Sundara Rao, B.Sc. (Hons.),Ph.D., Assoc I.A.R.I.—upto 6-9-58.
Dr. V. Ishwaran, M.Sc., Ph.D.—from 7-9-57.

Lecturer in Entomology . . . Vacant.

Lecturer in Physics . . . Vacant.

Lecturer in Agricultural Engineering . Vacant.

Lecturer in Veterinary Science . Dr. Gian Singh, L. V. P. (Hons.) —upto 16-7-58.

Lecturer in Horticulture . . . Dr. G. S. Randhawa, M.Sc., M.S.A., Ph.D. (Toronto) Ph.D. (Mich.)—upto 20-7-56.
Shri N. Nath, M.Sc., (Cal.) —from 21-2-57.

Lecturer in Mycology . . . Vacant.
Shri S. D. Gera, M.Sc.—from 22-12-56.

Lecturer in English . . . Shri S. L. Vachher, B.A. (Hons.), M.A.

Lecturer in Economics . . . Shri A. S. Kahlon, M.A.

Lecturer in Botany . . . Shri B. S. Fozdar, M.Sc.

I. A. R. I. DISPENSARY

Civil Asstt- Surgeon . . . Dr. R. K. Jerath, M.B.,B.S.

(b) Meetings, Conferences and Deputations

As in the previous years, the Director, the Heads of Divisions, and senior members of the staff attended meetings sponsored by the different Ministries of the Government of India, Indian Council of Agricultural Research, the different Commodity Committees etc. Dr. R. S. Vasudeva, Joint Director and Head of the Division of Mycology and Plant Pathology, visited the U.S.S.R. from 30th April 1958 to 21st May 1958 as a member of the Indian Scientists Delegation. Dr. P. C. Raheja, Head of the Division of Agronomy, visited Sudan from the 5th January to 21st January, 1958, to serve on the Agricultural Advisory Committee. Shri N. M. Nimgade, Research Assistant of the Division of Soil Science and Agricultural Chemistry went on special leave from 20th September 1957 for three years for higher studies in the U.S.A. Dr. B. V. Subbiah, Asstt. Soil Chemist, went on deputation to the U.S.A. from 14th March 1957 to 14th August 1957 for specialisation in soil testing and soil fertility investigations under the Expanded Technical Assistance Programme of the F.A.O.

(c) Visitors

The Institute is visited by a large number of foreign dignitaries and scientific and industrial delegates visiting India on any mission. The visitors include eminent scientists and important public men, from India and abroad. During the year, important visitors, among others, included His Majesty the King of Afghanistan; His Excellency Dr. Ho Chi Minh, the President of the Democratic Republic of Viet Nam; His Excellency the Prime Minister of the Rumanian Peoples' Republic; His Excellency the Prime Minister of Czechoslovakia; Mr. Balafrej, Minister for Foreign Affairs, Morocco; The Hon'ble Minister for Education, Mauritius; the Hon'ble Mr. D. Heathcoat, Minister of Agriculture, U.K.; Shri E. M. S. Namboodripad, Chief Minister, and Shri Achutha Menon, Minister for Finance and Agriculture, Kerala State; Prof. P. Sevic, Vice-President, Atomic Energy Commission, Yugoslavia; Sir Ian Clunies Ross, Chairman, Commonwealth Scientific and Industrial Research Organisation, Australia; Mr. Wilhelm Billing, Commissar for Atomic Energy, Poland; Shri C. D. Deshmukh, Chairman, University Grants Commission, India; Prof. Eudes De Souza Leao Pinto, Professor, Rural University, Brazil; Dr. Y. Tazims Head of the Morphological Genetics Division, National Institute of Genetics, Mishima, Japan; Dr. Itsquov, Director, Institute of Medicinal Plants, U.S.S.R.; Mr. R. N. Davies, Director of African Agriculture, Rhodesia; Dr. Charles E. Kellogg, Deputy Chief, U.S.D.A. Soil Conservation Service, Washington, U.S.A.; Mr. E. V. Schver, a soviet plant pathologist.

A number of delegations also visited the Institute. Important among them were: The Delegates to the Second FAO Development Centre on Farm Planning and Management; Delegation of USSR Farmers; Commonwealth Parliamentary Delegation; Trade-*cum*-Goodwill Delegation from Ghana; Russian Women's Delegation; Japan Diet Delegation; Armed Forces Delegation from the People's Republic of China; Party of 29 Tribal Chiefs; the Delegates to the WHO Seminar; Delegates to the FAO|ECAFE Centre on Policy to Support and Stabilise Agricultural Prices and Income in Asia and the Far East.

(d) Library

Fifty-three new periodicals were added to the list of periodicals, thus oringing the total number of periodicals to about 1,200. The total number of publications received, either by purchase or through exchange, was

4,246. 7,049 books were issued out on loan during the year, of which 718 books were sent outside to the scientific workers in different States and the Universities. 16,842 readers made use of the reading room and consulted 70,641 publications. In addition, references on topics concerning publications on specific subjects were supplied by the Librarian and his staff; these were on books on agriculture and on gardening, important journals published in India in the field of agriculture, list of publications by the members of the staff of the Institute, etc.

(e) Collections and Herbaria

The foreign plant introduction and indigenous collection during the year numbered 1,298 and 1,441 items respectively, bringing the total collection to over 19,500 items. Important among the introductions were in the case of sorghum, pearl millet, and horticultural plants.

Thirty specimens of insect species so far totally unrepresented, or very poorly represented, were added to the National Pusa Insect Collection. In addition, over five hundred other insect specimens have been collected and added to the general collection pending identification.

During the period under report, 17 fungal and bacterial cultures were added to the Indian Type Culture Collection in the Mycology Division bringing the total number of cultures to 1,100. In addition, 54 cultures of 13 different rusts on various crops and 46 cultures of various viruses are being maintained. About 172 cultures were supplied to various scientific workers and research institutions in the country and abroad. A consolidated list of the cultures maintained in the collection has been prepared and brought up-to-date. Studies on mineral oil and soil preservation of fungi were continued. In all, 537 mycological specimens (both Indian and foreign) were added to the Mycological Herbarium during the year, bringing the total number of accessions to 25,945. 112 specimens of fungi, including several types, were supplied to various Indian and foreign workers. An *exsiccati* set on "Indian Erysiphales" is under preparation. A list of specimens available in the Herbarium is being completed.
compiled.

(f) Research Schemes

Work on the following research schemes, financed by the Ministry of Agriculture, Government of India (including the Second Five Year Plan Schemes), Indian Council of Agricultural Research, and the different commodity committees, was in progress in the different Divisions of the Institute during the year under report:—

Title of the Scheme	Sponsored by
Division of Agronomy	
Project for Investigation of Weed Control . . .	Govt. of India, Ministry of Food & Agric.
Project of Irrigation Investigation	Do.
Project for Plant Tissue Tests and Spray fertilization .	Do.
Project for setting up Post-graduate course in Agricultural Extension	Do.
Scheme on the Improvement of Pasture Grasses .	I.C.A.R.
Agronomical Studies on Oilseeds	I.C.O.C.

Title of the Scheme	Sponsored by
Division of Botany	
Establishment of Plant Introduction and Exploration Organisation	Ministry of Food & Agri.
Coordinated Wheat Rust Control Scheme	Do.
Scheme for the Control of Bunt disease in Wheat	Do.
Scheme for Studies on the Milling, Baking and Chapati-making qualities of Indian Wheats	Do.
Scheme for Use of Radio-active Isotopes in Cytogenetic Studies	Do.
Establishment of a Unit for Embryo Culture Work	Do.
Scheme for the Setting up of a Central Seed Testing Station for Vegetable Crops	Do.
Establishment of a Wing for Fundamental Plant Genetical Research	Do.
Scheme for the Setting up of a Cobalt-60 Field Radiation Unit	Do.
Expansion of the Botanical Sub-station, Pusa (Bihar)	Do.
Scheme for Establishment of Vegetable Breeding Sub-station of the I.A.R.I. in Kulu Valley	Do.
Co-ordinated Maize Breeding Scheme	I.C.A.R.
Co-ordinated Scheme for Improvement of Chillies	Do.
Co-ordinated Scheme for Research on Micronutrients with Special Reference to Citrus—Die-back	Do.
Scheme for Improvement of Essential-oil Yielding Plants	Do.
Scheme for the Study of Genetics and Variability of Algae from the view-point of their use in Agriculture	Do.
Co-ordinated Scheme for Improvement of Musk Melon and Water Melon	Do.
Co-ordinated Scheme for Pre-Soaking Seeds in Nutrient Salts	Do.
Scheme for Cytogenetical and Physiological studies in relation to Floriculture	Do.
Project for Intensification of Regional Research on Cotton, Oilseeds and Millets	Do.
Scheme for Physiological Investigations on Autotetraploids of some Oilseed Crops	I.C.O.C.
Scheme for Cytological studies on some Oilseed Crops	Do.
Study of the Role of Trace Elements on the Metabolism of Cotton Plant	I. C. C. C.
Division of Soil Science and Agricultural Chemistry	
Radio-Tracer and Related Investigations	Ministry of Food & Agric.
Unit of Physics	Do.
Staff for working the Electron Microscope	Do.
ecqliar Application of Nutrients to Crops	I.C.A.R.
EioamlfoFmmining the Behaviour of certain additional exchFeaSCrertilizers under Storage Conditions	Do.

Title of the Scheme	Sponsored by
Division of Entomology	
Termites Research Scheme	I.C.A.R.
Toxicity Hazards Scheme	Do.
Nutritional and Biological Studies	Do.
Insect Physiology Scheme	Ministry of Food & Agric.
Storage Pest Ecology	Do.
Biological Testing of Insecticides	Do.
Survey of Beneficial Parasites	Do.
Radio-active Isotopes	Do.
Indian Honey Bee	Do.
Locust Toxicology	Do.
Division of Horticulture	
Establishment of the Division of Horticulture at the I.A.R.I.	Ministry of Food & Agric.
Division of Mycology and Plant Pathology	
Co-ordinated Plant Virus Diseases Scheme	Ministry of Food & Agric.
Scheme for Use of Atomic Energy in Plant Pathological Research	Do.
Scheme for Study of Bacterial Plant Pathogens	Do.
Appraisal of Losses due to Plant Diseases	Do.
Scheme for Testing of Fungicides	Do.
Bunt Control Scheme (Mycological Portion)	Do.
Scheme for setting up Seed Testing Station (Mycological Portion)	Do.
Plant Introduction and Exploration Organisation (Mycological Portion)	Do.
Scheme for Research on Diseases of Sugarcane	I.C.S.C.
Scheme for Research on Virus Diseases of Oilseed Crops	I.C.O.C.
Linseed Rust Scheme	Do.
Co-ordinated Scheme for Improvement of Chillies (Pathological Portion)	I.C.A.R.
Co-ordinated Wheat Rust Control Scheme (Mycological Portion)	Do.
Co-ordinated Plant Virus Research Scheme for Eastern Zone	Do.
Division of Agricultural Engineering	
Survey of Indigenous Agricultural Implements in Common Use in the Country	I.C.A.R.

(g) Post-graduate Training

Out of a total of 298 applicants, 96 students were selected and admitted to the regular two-year post-graduate training course (Diploma of Associateship of the I.A.R.I.) and four were admitted to the one-year Plant Protection course.

Ten students received training under the three-month course on the use of radio-isotopes in agriculture. Fourteen students were given training in the various Divisions. Five honorary research workers and fourteen research fellows were provided with facilities for research in the various Divisions.

Eighty-seven regular students and three departmental candidates passed the final examination and were awarded the Diploma of Associateship of the Institute (*vide* list of students, research fellows and honorary research workers, given at the end of the report).

(h) Intensive Cultivation Scheme

As in the previous years, the Institute operated this project in a block of 19 villages in Delhi State. It could justifiably be said that the work done by the Institute in these villages during the past eight years has left its mark on the agriculture of these villages. For instance, the progress of saturation with the improved wheat variety, N.P. 718, has been gratifying; 4,061 acres were planted to this variety this year, as compared to 2,775 acres last year and about 10 acres during 1950-51. The acreage under improved varieties of other crops, such as barley, oats, gram, peas, bajra and vegetables has also increased considerably. During the year under report, 437 field demonstrations of improved varieties of crops and of improved manurial and fertiliser practices were conducted on cultivators' fields. In addition, 336 saplings of shade trees and fruit trees were planted in the different villages. The pest control operations covered an area of about 542 acres, which included the control of the field rat menace over an extensive area. About 564 maunds of seeds of various crops were given fungicidal treatment and an effective control of the "*tundu*" disease of wheat was achieved by removing the *tundu* galls by the simple method of floatation in water from about 282 maunds of seed. Demonstrations of the use of agricultural implements were carried out and about 3,000 maunds of wheat grain were threshed for the cultivators, using the Olpad and the Ludhiana threshers. Soil fertility maps of six villages were prepared and the preparation of such maps for three other villages was in progress. Farmers were much impressed by the demonstrations of chemical control of weeds, using 2, 4-D. The increases in wheat yields achieved from such treatment ranged from 4·6 to 42·6 per cent. depending on the degree of infestation. A number of Farmers' Meetings were organised from time to time for surveying problems and suggesting solutions. Eight post-graduate students carried out investigations in agricultural extension in these villages in connection with their thesis work.

(i) Supply of pedigree seeds

As in previous years the demand for seeds of strains bred at the Institute, especially of wheat, from the different States was quite heavy. Since the area available for seed multiplication purposes was limited, the supply

of seed fell short of the demand. The following quantities of pedigree "N.P." seeds of different crops were supplied by the Institute:—

Crop	Quantity of seed distributed Mds.	Srs.
Wheat	2420	0
Paddy	147	13
Maize	137	0
Gram	72	6
Arhar	44	13
Barley	24	30
Oats	12	31
Mung	8	27
Linseed	5	38
Berseem	2	28
Cowpea (Fodder Type)	2	16
Sesamum	1	37
Dhaincha	1	20
Safflower	0	26
Bajra	0	8
Lentil	0	8
Urid	0	6
Brassica	0	5
Jowar	0	2
Tobacco	0	0·4
Vegetables (including peas and cowpea)	129	0

(j) Advisory

Besides the advisory committees of the Ministry of Food and Agriculture and of the Indian Council of Agricultural Research, including the Commodity Committees under the same Ministry, the Director served on numerous other expert committees constituted from time to time by the various scientific organisations in India.

In addition to the normal activity of research and training, numerous enquiries are received seeking advice on various specific problems such as cultivation practices, application of manures and fertilizers, supply of pedigree seeds, cultivation of specific crops, analysis of soil and water for irrigation, identification of diseased specimens of fungal and bacterial cultures, cultivation of vegetables, etc. Of the numerous types of requests for advice which were attended to, only a few are given below.

Agronomy.—Use of weedicides; legumes and grasses suitable for soil conservation and pasture purposes; response of berseem to smaller doses of nitrogen in conjunction with phosphate; green manuring; overhead irrigation and irrigation machinery; cultivation of tapioca; introduction of herbage plants for the humid and sub-humid regions; cultivation of specific crops like potato, wheat, maize, *guar,* Hubam clover, paddy, soybean, sugarcane, etc.; water requirements of crops; maturity, weaning, and feeding of dairy cattle; feeding scales of the bullocks.

Botany.—The items covered a variety of subjects, such as methods of cultivation of improved "N.P." varieties of crops and vegetables, identification of plant specimens, use of certain chemicals and fixatives, control of weeds, etc.; detailed information on the production of Annato (*Bixa arellana*) seed in India and its export to the USA; information on breeding and genetics of crop plants in India to the Ministry of Agriculture, France; method of cultivation of Pusa Ruby tomato and Pusa Katki cauliflower; cultivation of Russian Comfrey (*Symphytum officinale*); resistance of Indian varieties of cowpea to the insect pest, *Curculionides*.

Chemistry.—Advice was given and information was supplied on the use of radio-isotopes in agriculture; manufacture of dicalcium phosphate and its uses; conservation of human urine for manurial purposes; storage of superphosphate in alkathene-lined gunny bags; methods of improving soil structure. Frequent enquiries regarding cow-dung gas plants were replied to.

Entomology.—Identification of a large number of specimens of insects; suggestions regarding the control of pests; supply of coloured plates of insects and pests; examination of seeds of various crops and of banana suckers, rose saplings, cuttings of *Cynodon dactylon* and a few varieties of grapes.

Mycology.—Identification of diseased specimens as well as of fungal cultures received from different sources in the country and enquiries from scientific workers regarding control measures of bacterial diseases were attended to.

Agricultural Engineering.—Advice regarding selection, use and operation of agricultural machinery; technical advice on mechanised agriculture; import and export policies relating to the field of agricultural implements and appliances; selection, procurement, installation, operation and maintenance of agricultural machinery and equipment in the other Divisions and Sub-stations of the Institute.

Horticulture.—Preservation of mango fruits in their natural colour for exhibition purposes; losses of fruit during shipment due to defective packing and improvement in packing; details of papaya cultivation; information on the chemical composition of banana; improved methods of vegetable cultivation; control of fruit cracking in pomegranate; details of grape cultivation; setting up of a vegetable seed testing laboratory; different aspects of vegetable cultivation.

The Chief Soil Survey Officer advised on the setting up of a soil survey organisation in connection with the settlement of Bengal refugees in the Dandakaranya area, and also on the finalisation of the scheme of soil survey of coconut-growing area as required by the Indian Central Coconut Committee.

(k) Land and Buildings

No land was acquired during the year. The following buildings were completed.

1. Machine shed in the Division of Entomology.
2. Museum for agricultural implements.
3. Workshop and office buildings of the Division of Agricultural Engineering.
4. Extension to Director's office.

5. Soil Correlation Laboratory in the Division of Chemistry.
6. Completion of fencing.
7. Open surface well at Indore.
8. Seed Drying, Processing and Storage Shed in the Division of Botany.

The following construction works were taken up during the year and are in progress:

1. Assembly Hall.
2. Eight DII type quarters.
3. Circular wall of the 'Gamma Garden' (Cobalt-60 field).
4. Residential quarters under the Second Five Year Plan.

(l) Accounts (Expenditure)

The total expenditure on the Institute and its Sub-stations during the financial year ended 31st March, 1958 amounted to Rs. 47,91,904 only, as per details given below:

		Rs.
I.	(*i*) General expenditure on the Institute, including the office of the Director, estate establishment, I. A. R. I. dispensary	10,21,133
	(*ii*) Statistics Section	30,328
	(*iii*) Division of Soil Science and Agricultural Chemistry	10,30,843
	(*iv*) Division of Mycology	4,26,264
	(*v*) Division of Entomology	3,06,295
	(*vi*) Division of Botany	8,24,033
	(*vii*) Division of Agronomy	5,36,834
	(*viii*) Agricultural Economics Section	8,535
	(*ix*) Division of Agricultural Engineering	1,84,667
	(*x*) Central College of Agriculture	1,54,145
	I.	45,23,077
II.	Experimental Farms :	
	Agricultural Sub-station, Karnal	1,46,420
	Botanical Sub-station, Pusa Bihar	73,590
	Central Vegetable Breeding Sub-station, Katrain	48,817
	II.	2,68,827
	TOTAL	47,91,904

PART—II

REPORTS OF THE HEADS OF DIVISIONS FOR 1957-58

Report of the Division of Agronomy

(Including Agricultural Research Sub-station, Karnal)

(DR. P. C. RAHEJA)

1. *Weather and its effect on crops*:

The relevant data of monthly means is reported as under:—

TABLE I

Weather data for 1957-58

	Temperature °C				Rainfall in mms.		Humidity	Wind velocity	Sun shine	Evaporation
Month	Mean Max.	Dep. from normal	Mean Min.	Dep. from normal	Total rainfall	Dep. from normal	Relative humidity at 7 A.M. local	Mean velocity in km/hr.	mean hrs. of bright sunshine	mean evap. in mm/day
July 57	35·1	—0·3	26·7	—0·3	282·7	+89·7	79·9	10·3	5·5	10·4
Aug. 57	33·8	+0·6	26·0	—0·1	86·6	—65·8	84·5	7·3	7·6	7·0
Sept. 57	31·5	—2·2	22·1	—2·1	184·6	+70·8	82·8	7·7	6·4	6·5
Oct. 57	32·5	+0·4	16·6	—1·0	16·3	—45·4	72·2	5·3	9·7	6·4
Nov. 57	27·7	+0·1	11·2	+1·5	8·6	+6·6	78·8	3·6	9·4	4·5
Dec. 57	21·3	—1·3	8·0	+1·7	16·0	+15·0	88·0	3·9	7·6	2·6
Jan. 58	21·9	+1·7	7·3	+0·6	8·7	—14·2	89·6	2·8	7·2	2·2
Feb. 58	23·8	+0·6	7·1	—0·5	0·0	—16·3	81·0	4·3	8·7	4·0
March 58	30·3	+1·4	13·1	+0·1	20·8	—3·8	70·7	5·4	8·8	7·2
April 58	38·2	+2·2	21·0	+2·6	1·5	—5·2	41·7	6·7	8·8	11·2
May 58	40·3	+0·2	23·0	—1·5	4·8	—4·7	30·3	6·2	7·8	14·2
June 58	41·3	—1·2	27·2	—0·3	3·1	—28·8	44·2	10·9	7·3	16·3

The rainfall received during the year was 633·6 mm. which was 4·2 mm. below normal. Weather in July was favourable for the *kharif* crops, but in August it was rather dry. The dry season during October adversely affected the *kharif* crops. Early *rabi* crops were sown with September rainfall. Late *rabi* crops were sown after irrigation. They, generally, germinated satisfactorily. The failure of rains after December adversely affected the ultimate yields of *barani* crops. Irrigation was required to mature them.

The yields of principal crops grown on the Agronomy farm were as follows:—

TABLE II

Average Yield of Crops

Crops	1956-57 Av. yield mds/acre	1957-58 Av. yield mds/acre
Wheat	11·3	15·9
Oats	11·8	19·7
Peas	10·7	8.1
Gram	5·1	7·9
Berseem	464·0	469·3
Maize	10·4	17.6
S. cane (stripped)	589·0	526·5

II. Research Projects

The research programme of the Division is divided under the following Sections:—(i) Soil Fertility; (ii) Field crops; (iii) Vegetable and commercial crops; (iv) Farm and cattle; and Schemes on (a) Fertilizer use; (b) Weed control; (c) Irrigation Investigations; (d) Agricultural Extension and (e) Plant tissue tests and spray fertilization. The experimental results are detailed as under:—

(i) *Soil Fertility Section:*

1. *Building up of soil fertility through organic manures including green manures and inorganic fertilizers.*—This project was started in 1950-51 to evaluate the direct effect of organic manures alone and in combination with inorganic fertilizers on wheat and the residual effect on maize and wheat in the *wheat-maize-wheat* rotation. In the fourth cycle of the rotation *wheat-maize-wheat*, completed during the year. The yields of maize and wheat crops in the residual phase were:—

TABLE III

Soil-fertility Building through organic and inorganic manures

Main Plot treatments (Organics applied for 1st wheat crop)	Yield in mds/acre	
	Maize	Wheat
Control	18·20	9·20
Guar G.M.	22·3	10·6
Castor cake 60 lb. N/acre	19·7	11·4
F.Y.M. ,, ,,	20·6	10·6
S.Em.	±0·45	±0·73
C.D. at 5%	1·66	Not sig.

Sub-plot treatments (Inorganics)	Yield in mds/acre	
	Maize.	Wheat
Control	20·5	9·8
40 lb. N/acre	20·7	10·6
80 lb. P_2O_5/acre	20·1	9·8
40 lb. N_2+80 lb. P_2O_5	19·3	9·8
40 lb. N+80 lb. P_2O_5 + 40 lb. K_2O	19·7	10·1
S.Em	±0·79	±0·42
'F' test	Not sig.	Not sig.

2nd-split (dose of N)	Yield in mds/acre	
	Maize	Wheat
N_0—Control	17·1	9·4
N_1—30 lb. N for Maize +20 lb. for wheat	23·3	11·5
S. Em	±0·87	±0·83
C.D. at 5%	2·11	2·01

In the residual phase the effects of basal treatments were exhibited in the maize crops (significant at 5 per cent.) but not in the succeeding wheat crop. This indicated that residual effects even in the fourth cycle of the rotation were short-lived. The direct application of nitrogen at 30 lb. for maize and 20 lb. for wheat were shown to be significant, the differences respectively were 6·2 and 2·2 md./acre.

2. *Building of soil fertility through organic manures and inorganic fertilizers in the cereal and legume rotation.*—The object is to study the possibility of growing *bajra* and wheat or legumes in the same year with heavy manuring under irrigation. The experiment is so designed that it will be possible to study the direct residual and 'split-up' application effects of the F.Y.M. on the various crop included the rotations. The principal cereal crops in the experiment are *bajra* and wheat. Wheat after *bajra* yielded 15·7 mds. as compared to 24·2 md. per acre after fallow. The differences among the nitrogen levels were also quite appreciable. Fertilizer nitrogen applied at the rate of 30 lb. acre yielded 25·1 as compared to 17·1 md. per acre without nitrogen.

3. *Building up of soil fertility through organic manures and inorganic fertilizers in (a) cereal rotation; and (b) legume rotation.*—The rotations followed in the experiment are (a) *Maize-Wheat* and (b) *Maize-wheat-maize-peas.* The results confirm the beneficial effect of legume in the rotation. The differences in response to manures and fertilizers were not significant on *kharif* crops, though the treatment effects were superior to the control. The differential effect of treatment on the *rabi* crops were significant. In wheat NP and NPK treatments gave 21·4 and 21·8 md/acre respectively against 14·1 mds/acre in control, followed by castor cake, F.Y.M. In peas, NP and NPK and F.Y.M. and castor cake gave significantly higher yield than the control. The manures had been applied in full dose to the maize crop and the fertilizers in half doses to the *kharif* and the *rabi* crops respectively. The residual effect of castor cake applied to maize was quite substantial on wheat. The application of F.Y.M. and castor cake showed significant responses in the yield of peas. The effect of potash was not very much indicated.

4. *Effect of low doses of phosphate on berseem and after effect on wheat.*—This is the third cycle of this experiment to study the rate of deterioration in soil fertility in the *berseem-berseem-cowpeas/fallow-wheat* rotation. The residual effect of doses of organic and inorganic P_2O_5 in F.Y.M. and superphosphate applied to soil for berseem are studied on cowpeas/fallow-wheat crops.

The results are given below:—

TABLE IV

Effect of low doses or phosphate on berseem and after effects on wheat.

Average yield in md. per acre

Treatment per acre (to berseem)	Mean yield of berseem green fodder (1955-57)	Cowpeas green fodder	Wheat C-518		
			C—W	F—W	Average
A. F.Y.M. 16 lb. P_2O_5 . .	194·01	63·47	16·27	20·68	18·47
B. ,, 32 lb. ,, . . .	350·50	97·45	19·57	19·80	19·69
C. ,, 64 lb. ,, . . .	418·20	123·77	24·51	24·87	24·68
D. Super 16 lb. ,, . . .	266·61	66·46	20·07	20·74	20·39
E. ,, 32 lb. ,, . . .	356·57	85·87	19·24	25·03	22·13
F. ,, 64 lb. ,, . . .	506·49	115·00	24·25	25·58	24·91
G. Super 8 lb. P_2O_5+F.Y.M. 8 lb. P_2O_5	231·78	68·51	16·14	20·92	18·54
H. ,, ,, + ,, 24 ,,	336·80	77·29	16·72	23·42	21·07
I. ,, ,, + ,, 56 ,,	513·05	120·22	25·29	23·50	24·39
J. F.Y.M. 8 lb. P_2O_5+Super 24 lb. P_2O_5	352·52	97·08	22·03	23·33	22·59
K. ,, ,, + ,, 56 ,,	467·96	83·63	22·24	25·28	23·73
L. No manure	117·40	64·21	14·06	16·72	15·39
M. Fallow in *rabi* when berseem was grown	..	80·27	13·48	20·25	16·56
'F' test . .		Sig. 5%	Sig. 1%	Sig. 1%	
S. Em. . .		±12·33	±1·42	±1·c	
C. D. at 5% .		36·02	4·03	2·79	

In the residual phase the differences in yield of cowpeas were manifested to be significant. The residual response increments were directly related to doses of phosphate applied for berseem crop. The yields of wheat after cowpeas were lower than after fallow indicating that soil nitrogen had been exhausted by cowpeas and fallow had enriched the soil. The fertility of the 'no manure' plot under berseem was slightly lower than of the fallow plot without berseem. Obviously, without phosphate, the fixation of nitrogen is very much restricted.

5. *Effect of phosphate with and without potash and/or nitrogen on berseem and after effect on maize, cotton and wheat.*—The experiment started in 1948-49 has two rotation series:

(i) Berseem-maize-berseem-cotton-wheat
(fertilized) (un-fertilized)

(ii) Berseem-maize-berseem-cotton-wheat
(ferti- Un-) = (fertilized) (Un-fertilized).
lized) fertilized)

The third cycle of the rotation was completed in 1956-57. In this year berseem was sown in both the series. The residual effect of fertilizers after third cycle of the rotation were as under:—

TABLE V

Effect of Phosphate with and without Potash and/or Nitrogen on Berseem

Treatments/acre			Yield of berseem green fodder in md/acre	
N	P_2O_5	$K_2°$	Series I	Series II
lb.	lb.	lb.		
C	0	0	0	221·21	297·72
P	0	120	0	361·16	669·22
PK	0	120	120	375·04	632·06
N_1P	25	120	0	361·02	624·85
N_2P	50	120	0	367·83	647·31
N_3P	100	120	0	384·98	635·73
N_3PK	100	120	120	375·32	627·43
S.Em.				±23·25	±24·07
C. D. at 5% level				68·00	69·51

The residual effect of phosphate was significantly higher than the control in both the series. There was no residual effect of N or potash In series II, the persistance of residual phosphate affect is 75 per cent. more than in series I in which the berseem had twice received the fertilizer. Obviously, the residual effect of phosphate persists over a long period of time for subsequent crops to utilize it.

6. *Phosphate fertilization of legumes under rainfed conditions.*—This experiment was started to investigate (i) whether the yield of *guar green* fodder is increased significantly by phosphate fertilization and; (ii) if it is possible to obtain more yield of wheat after phosphate fertilization of *guar* fodder than after *kharif* fallow. The results indicate that *guar* responds significantly to phosphate fertilization at 75 lb. P_2O_5 per acre. The wheat yield was higher after *kharif* fallow, than after phosphate application to the soil. Instead of building up soil nitrogen the *guar* in spite of phosphate fertilization, depleted it.

7. *Effect of phospho-bacterium inoculation of berseem seed on yield and* P_2O_5 *availability.*—The project had been initiated in collaboration with Chemistry Division. Phosphate was applied to maize and berseem from different materials, *viz.*, bone meal, rock phosphate, superphosphate and F.Y.M. and the effect was studied on yield with and without Fosfo.

24, a bacterial culture from U.S.S.R. An Indian culture was also included for comparison.

Inoculation of maize seed with Fosfo. 24 in conjunction with bonemeal and rock phosphate significantly increased the yields over these materials applied without inoculation. The increase in yield varied from 22·5 to 24·4 md/acre as compared to 19·9 md. under control. In case of berseem, inoculation of seed with and without phosphate applied as bonemeal, rock phosphate or F.Y.M. had no significant effect on yield.

8. *Comparative effect of different systems of rotations.*—This was the seventh year of the experiment which has 10 rotation of different cropping intensities including fallow and green manure crops. Different rotations indicated significant differences in the yields of maize, potato and wheat crops.

In general, it was concluded from the results that wheat crop following the heavily manured and fertilized crops of potato, sugarcane and maize gave higher yield than after fallow or even green manure. The effect of green manure on wheat yield was superior to that of fallow. The yield of maize was much higher after potatoes than after wheat. Similarly, effect was noted on sugarcane crop. Cotton yields were similarly influenced due to heavy manuring to the preceding crop in comparison to cotton succeeding fallow.

9. *Hubam clover as mixed crop in wheat-maize cereal rotation.*—Investigations were taken up in 1955-56 to maintain the yields of maize and wheat crops in a purely cereal rotation by introducing hubam clover as a mixed crop in wheat. Several combinations of fertilizers were included to assess the fertility built by hubam clover in the rotation.

TABLE VI

Effect of Phosphate with and without Potash and/or Nitrogen on Berseem

Treatment per acre	Average yield in md. per acre	
	Maize. No. 2	Wheat N.P. 718
A. Wheat-fallow : no manure	..	23·80
B. Wheat-maize : 40 lb. N to wheat	19·18	26·80
C. Wheat-maize : 40 lb. N to maize	25·71	16·95
D. Wheat-maize : 40 lb. N to each crop	28·71	26·12
E. Wheat and clover for fodder and G.M.—maize : no manure.	22·20	19·34
F. Wheat and maize : 40 lb. N to maize	27·01	18·54
G. Wheat and maize : 80 lb. P_2O_5 to clover	21·32	19·12
H. Wheat and clover for G.M. only—maize : no manure	27·91	19·86
I. Wheat and Maize : 40 lb. N to maize	32·35	18·78
J. Wheat and maize : 80 lb. P_2O_5 to clover	27·27	22·89
K. Hubam clover G.M.—maize : no manure	33·11	..
L. Wheat—San-G.M. : no manure	..	27·16
'F' test	Sig. 1%	Sig. 5%
S.Em.	±2·28	±2·15
C. D. (5%)	6·60	5·88

The yield of maize and wheat were well maintained by green manuring hubam clover in the soil for maize crop. When 80 lb. of P_2O_3 was about 3·7 md./acre. The residual response due to hubam clover green manuring appears to equal about 30 lb. N per acre. The residual response of 80 lb. P_2O_5 to clover corresponds to a dressing about 20 lb. N/acre for wheat crop. The application of 40 lb. N separately for maize and wheat crops gave the highest out-turn per acre.

II. Field Crops Section

1. *Response curve of nitrogen with New Pusa wheat varieties.*—In the third year of the experiment, N.P. 718 gave the highest yield (22·36 md./acre). The yield of wheat increased with increase in dose of nitrogen. 20 lb. dose of N was significantly superior (21·8 md./acre) to Control (16·3 md/acre). Application of P alone or in combination with 80 lb. N/acre gave no advantage. The is in confirmation with the results obtained last year. Although there were indications that different varieties respond differently to nitrogen applications, the differences were not statistically significant. Last years' varieties showed significant differential responses to doses of nitrogen.

2. *Optimum seed rate, spacing and date of sowing for wheat varieties N.P. 710 and N.P. 718.*—Wheat varieties N.P. 710 and N.P. 718 were sown at the rate of 50,70 and 90 lb. seed per acre. The differential spacings between rows adopted were at 6″, 9″ and 12″. The three respective dates of sowing were Oct., 25, Nov. 12, and Dec. 1. Date of sowing made marked differences in the yield. Highest yield (26·2 md./acre) was obtained when wheat was sown on Oct. 25 and lowest (21·7) of the December 1 sown crop. N.P. 718 yielded significantly higher than N.P. 710. No significant differences were found either due to seed rates or row spacings.

3. *Optimum time of application of F.Y.M. to N.P. 710 wheat.*—Application of F.Y.M., 3 months, two months and one week before sowing wheat did not show significant effect on yield (20·3 to 23·0 md./acre). Doses of F.Y.M. 2·5 and 10 tons per acre, however, made significant differences. The increase in yield with 10 tons F.Y.M. was 2·6 md./acre. The application of inorganic nitrogen significantly increased the yield by 2·0 md. Thus, the nutrient effect of 10 tons of F.Y.M. did not exceed 15 lb. of fertilizer nitrogen.

5. *Tillage experiments on Bajra and wheat under rainfed conditions.*—experiment was conducted in collaboration with Chemistry Division. The treatments were 40 lb. N; 40 lb. N +80 lb. P as under and 40 lb. N + 80 lb. P_2O_5 as dicalcium phosphate. The effect of dicalcium phosphate applied to soil was equal to the superphosphate on the wheat grain yield. The application of phosphate influenced the yield of maize to a small extent.

5. *Tillage experiments on Bajra and wheat under rainfed conditions.* – This was the second year of the experiment for the study of the tillage

and interculture requirements of *bajra* and wheat crops. The results obtained are given below:—

TABLE VII

Effect of tillage on bajra and wheat.

Treatment (cultivation)	*Grain yield in md./acre*	
	Bajra T-55	Wheat N.P. 718
C1—Tractor ploughing 10″ deep followed by grubbing and discing	8·91	4·15
C2—Bullock soil inverting plough (Victory) 5—6″ deep followed by country ploughing	7·81	4·10
C3—Surface cultivation with harrow	7·74	3·22
'F' test	Sig. 5%	Not sig.
S.Em.	±0·39	±0·33
C. D. 5%	0·90	..
Inter-culture		
x = Interculture with bullock hoe	7·82	3·76
y = weeding with khurpi	9·01	3·99
z = control	7·65	3·73
'F' test	Sig. 1%	Not sig.
S.Em.	±0·39	±0·33
C.D. 5%	0·90	..

The grain yields of both the crops were low as the distribution of rainfall was dis-uniform. The winter-rains were received rather late and in small amount. Significantly higher yield was obtained by tractor ploughing the land up to 10 inches depth as preparatory tillage for *bajra* crop than other treatments. Similarly, hand weeding proved more beneficial than interculture. The treatment effects in case of wheat crop were small.

6. *Spacing-cum-varietal trial on pigeon pea.*—This project was started in *kharif* 1956 in collaboration with the Division of Botany to study the performance of recently evolved wilt-resistant varieties at the I.A.R.I. as compared to varieties already in vogue in the different States in relation to spacings and rates of fertilizer application. Under *barani* conditions the yield differences due to various treatments were not significant.

7. *Influence of fertilizer rates and periods of cutting on Blue Panic and rhodes grasses.*—Two separate experiments for comparing four

levels of Nitrogen (0,40,80 and 120 N/acre) and 3 intervals of cutting (20, 30 and 40 days) were started in *Kharif* 1955.

TABLE VIII

Effect of fertilizer rates and periods of cuttings on blue panio and rhodes grass

Treatments	*Green herbage yield—md./acre* Rhodes grass	Blue panic grass
Levels of Nitrogen:		
N_0 (No nitrogen)	123·7	38·7
N_1 (40 lb. N/acre)	152·5	53·8
N_2 (80 lb. N/acre)	206·0	70·6
N_3 (120 lb. N/acre)	242·8	139·7
'F' test	Sig.	Sig.
S.Em.	±18·5	±4·49
C.D. at 5%	79·7	13·17
C. D. at 1%	126·0	
Interval of cutting :		
C_1 (20 days)	177·9	64·6
C_2 (30 days)	202·6	73·7
C_3 (40 days)	170·7	88·7
'F' test	Not sig.	Sig.
S.Em.	..	±3·98
C.D. at 5%		11·4

The differences due to nitrogen levels were highly significant. In blue panic highest yield of 97·5 md./acre was obtained with lb. N/acre. Differences due to cutting intervals were significant. Maximum yield of 88·7 md./acre was realised when cut at 40 days interval. Generally, the yields were lower this year as compared with the previous years. The herbage yields of rhodes grass were much higher than of the blue panic. The degree of response to nitrogen was also proportionately more in the former than the latter. Thirty days cutting interval proved optimum period for maximum herbage yield.

8. *Grass Scheme (I.C.A.R.)*

(a) *Collection and testing of grasses and legumes.*—In the fifth year of the scheme about 66 seed samples were received and grown for observation. Regular agronomic observations were recorded on the material established. Six new grass species and 4 legume species were added to the existing collection maintained in the nurseries, thus bringing the total to 146 perennial grasses and 86 legumes.

In the yield trials, *Brachiaria mutica* under sewage irrigation and *chloris gayana* (giant Rhodes) under rainfed conditions gave the highest yield of green herbage. Out of the three grass legume mixtures, under study, Napier+Kudzu gave the highest yield, the herbage obtained was well balanced for greater part of the year.

(b) *Co-ordinated trials.*—In the coordinated trials conducted at centres representing different agro-climatic regions, the under-mentioned materials showed promise:—

	Grasses	Legumes
Zone I		
Rainfall 500—1000 mm.	1. *Chloris gayana* (Giant Rhodes)	1. *Mucuna-cochinchinensis* (Velvet bean)
	2. *Urochloa mosambicensis*	2. *Desmodium purpureum*
	3. *Cenchrus ciliaris* (Bold)	3. *Phaseolus lathyroides* (Phasemy bean)
	4. *Panicum maximum* (thin Gururea)	4. *Dolichos lab lab*
Zone II		
Rainfall over 1000 mm.	1. *Brachiaria mutica* (Para)	1. *Mucuna cochinchinensis*
	2. *Setaria sphacelata*	2. *Phaseolus lathyroides*
	3. *Chloris gayana* (Giant rhodes)	
	4. *Urochloa mosambicensis*	
	5. *Cynodon plectostachyum*	

Giant rhodes gress appears to have wide adaptability. Similar is the case of *Urochloa sp.* Amongst the legumes *Mucuna* has good possibilities as a legume forage.

(c) *Distribution of plant materials.*—About 855 seed samples of grasses and legumes and 260 dozen of kudzu (crowns) were supplied to 70 parties. Apart from this bulk quantity of seeds of Napier, Para, *Setaria*, Blue panic, Giant rhodes, *Anjan* and Sudan grasses and *Mucuna*, Hubam clover, Bur clover and soyabean legumes were sold to both private and Government parties.

9. *Oilseed Scheme (I.C.O.C.):*—

(a) *Effect of time of nitrogen application on linseed.*—The experiment was started with the object of studying the split up application of nitrogen doses on linseed at different times. Time of application in (full does at sowing; ½ at sowing and ½ one month after; ½ after one month ½ after 2 months), made small difference compared to the significant effect of nitrogen doses on the yield of linseed. Application of 40 lb. N dose appreciated the yield by 2·8 mds. of linseed. Such application proved highly remunerative.

(b) *Response of linseed to NPK fertilizers.*—The objects of this experiments is to study the effects of different levels of NPK fertilizers on linseed. The three levels of nitrogen are 0,30 and 60 lb. N per acre, that of P_2O_5 and K are, 0, 20 and 40 lb. per acre respectively.

TABLE IX

Effect of NPK fertilizers on linseed

Mean yield md./acre.

Levels of K_2O/acre: lbs.	Levels of N lb. pacre. 0			30			60			Mean for K	S.Em.	'F' test	C.D. at 5%	C.D. at 1%
	Levels of P_2O_5 lb./acre. 0	20	40	0	20	40	0	20	40					
0 lb.	13·06	14·63	11·61	18·50	17·53	18·71	19·95	20·66	19·42	±17·12	±0·22	Sig. 5%	0·656	..
20 lb.	13·74	12·32	11·08	15·07	17·50	17·75	18·25	19·10	20·80	16·18				
40 lb.	15·27	11·96	10·44	17·65	16·58	17·86	20·41	19·21	19·91	16·58				

Mean for NP	14·02	12·97	11·04	17·07	17·20	18·10	19·54	19·66	20·04

Interaction for NPK
±0·685 Sig. 1% 2·005 2·72

S. Em.	±0·389
'F' test	Sig. at 1%
C.D. at 5%	1·188
" 1%	1·550
Mean for N	12·68 17·46 19·75
S. Em.	±0·224
'F' test	Sig. at 1%
C.D. at 5%	0·665
" 1%	0·890
Mean for P	16·88 16·61 16·40
S. Em.	±0·224
'F' test	Not sig.

Levels of P_2O_5/acre	Levels of K_2O lb./acre 0	20	40
0 lb.	17·13	15·66	17·74
20 lb.	17·57	16·37	15·88
40 lb.	16·65	16·51	16·13

Interaction for PK

'F' test	Sig. at 1%
S.Em.	±0·389
C. D. 5%	=1·188
C. D. 1%	=1·550

Nitrogen application at the rate of 30 and 60 lb. N increased the linseed yield by 4·8 mds. (37·8 per cent.) and 7·07 mds. (59·7 per cent.) per acre respectively, over no fertilizer treatment.

The application of phosphate indicated no beneficial effect on yield. Potash reduced the linseed yield significantly. The interactions NP, PK, NPK were found to be significant. Obviously, the crop is extremely responsive to application of fertilizers to the soil.

III. Vegetable and Commercial Section

1. *Fertilizer experiment on cauliflower.*—For the third year confirmatory evidence of responses to levels of nitrogen (0, 60 and 120 lb.) and levels of P_2O_5 (0, 40 and 80 lb.) and levels of Molybdenum (0, 1 and 2 lb.) was obtained in this experiment. Responses to Nitrogen and phosphate levels were significant. The extra yields obtained with 60 and 120 lb. N were 59·1 and 93·4 mds. respectively. The increase of P_2O_5 from 40 lb. to 60 lb. did not indicate extra response in out-turn of cauliflower heads. The doses of M_0O_3 showed no effect on yield of cauliflower.

2. *Fertilizer-cum-cultural experiment on tomato.*—In the third year of the experiment, which includes three levels of nitrogen (30, 60 and 90 lb. N acre); three levels of P_2O_5 (20, 40, 60 lb. P_{25} acre) and three date of application of the fertilizers, the results rather unexpectedly showed no response to nitrogen levels and time of application of nitrogen to the crop. However, the yield increased significantly due to phosphate fertilizer application. These yields for the three respective levels were 169·9, 187·6 and 199·5 mds. per acre.

3. *Response of Peas varieties to different levels of nitrogen and phosphate.*—This experiment for the second year was conducted under *barani* conditions. The varieties N.P. 29, Early Badger and Bonneville were grown under three levels of N and three levels of P_2O_5 The standard variety on the average gave an out-turn of about 15 md. per acre.

TABLE X

Response of peas varieties to different levels of nitrogen and phosphate

	Out-turn of Peas green md./acre				
Varieties	Yield md/acre	Nitrogen lb./acre	Yield/md acre	P_2O_5 lb./acre.	Yield md/acre.
N. P. 29	15·27	0	13·03	0	12·89
Early Badger	5·68	10	13·73	30	13·45
Bonneville	21·04	20	15·41	60	15·83
'F' test			Not sig.		Not sig.
S.Em.	±0·85		±0·88		±0·88
C.D. 5%	2·60				

Bonneville gave significantly higher yield than N.P. 29 and Early Badger. Application of N and P_2O_5 had no significant effect. Varieties performed the same way last year also.

4. *Vegetable Growers Holdings.*—This project was started in 1955-56 to evaluate the economic production of 3-acre holdings. It is also aimed to produce sufficient food crops for the maintenance of an average family of a farmer and fodder for the cattle in addition to some cash from the sale of vegetables.

The highest profit of Rs. 308·94 per acre was obtained from holding manured with F.Y.M. followed by holding manured ½ with F.Y.M. and ½ with fertilizers. The holding treated with fertilizers alone gave a net loss of Rs. 643·00 per acre.

5. *Response of sugarcane varieties to nitrogen doses.*—This experiment was conducted to determine and compare the response curves of newly selected varieties with the standard variety CO·647.

TABLE XI

Response of Sugarcane varieties to Nitrogen doses
(Stripped cane yield md. per acre.)

Doses of nitrogen	CANE VARIETIES CO. 647	CO. 659	CO. 797	Co. 998	CO. 999	CO. 1109	Mean	S. Em.	C.D. a 5%
il .	510·6	557·7	441·8	522·5	701·6	628·6	560·6	±14·31	41·07
40 lb. .	667·9	563·8	518·2	660·0	592·1	599·4	600·2		
80 lb. .	597·2	660·1	601·6	688·0	685·0	632·9	644·1		
120 lb. .	683·6	629·4	605·1	709·4	110·8	625·9	660·7		
Mean .	614·8	602·8	541·7	645·0	672·4	621·7			
S. Em. .	±18·26								
C.D. at 5%]	57·54								

Interaction—V × N
S.Em. . ±35·06
C.D. at 5% 100·62

In the test the various varieties have exhibited differential responses to levels of nitrogen. This is indicated by the significant interaction between varieties and nitrogen levels. The cane out-turns of varieties CO999, CO998 and CO1109 were comparable. Variety CO999 only had given significantly greater out-turn than variety CO647. On the whole varieties gave increasing response to levels of nitrogen.

IV. Irrigation Investigations Scheme

1. *Relationship between cropping pattern and irrigation intensities:*—

This projects was started in *rabi* 1955-56 with 12 three-year rotations of different cropping intensities varying from 100 to 200 per cent and irrigation intensities varying from 45 to 200 per cent. The crops grown during the year under report were maize, jowar and cowpeas (fodder); sugarcane, cotton, potato, berseem, wheat. Sugarcane gave significant differences both due to different levels of irrigation and rotations. The medium delta of irrigation gave the highest yield (726·9 md./acre) which significantly exceeded the lowest level of irrigation (651·7 md./acre).

Sugarcane when planted in the standing crop of berseem significantly reduced cane yield (549·81 md./acre) than in other rotations, in which the out-turn of cane varied within small limits (782·2 and 722·1 md./acre).

As there was adequate and well distributed rainfall during the *kharif* season various levels of irrigations did not influence the yields of maize, grain, maize—cowpeas fodder and cotton. The potato crop was infected with "late blight" which very much reduced the yield of the crop and levels of irrigation could not manifest their influence.

Berseem received 33, 38 and 43 acre inches of water in addition to 2·2″ of rainfall. Yield under 38″ and 43″ irrigation (391·8 and 421·0 md./acre) respectively, were significantly higher than 33″ irrigation (380·4 md./acre).

Wheat yield increased significantly with increase in delta of irrigation. 11 acre inches of irrigation gave 29·6 mds./acre compared with 9″ which gave 28·5 md./acre. With 200 per cent. cropping intensity wheat yield was significantly lower as compared to 100 per cent. intensity of cropping. Generally, wheat after fallow gave significantly higher grain yield (31·9 to 34·3 md./acre) which compared favourably with wheat after potatoes, sugarcane or berseem in the previous year. Wheat after wheat, also gave high yields (28·6 to 32·5 md./acre). Wheat after jowar+cowpeas in *kharif* and wheat in the previous *rabi* gave lowest yield (20·5 to 23·4 md./acre) in different rotations.

2. *Response of wheat to jarying levels of irrigation, nitrogen doses and different seed rates*:—

In the third year, again, the effect of irrigation frequency (2, 3, 4 irrigation) in addition and 4″ soaking dose, nitrogen levels (20, 40, 60 lb. N/acre) and seed rate (40, 60, 80 lb./acre) were studied. The yield results are given below:—

TABLE XII

Response of wheat to varying levels or irrigation nitrogen doses and different seed rates.

Delta of irrigation +2.03″ rain.	Yield of grain md/acre.	Nitrogen levels	Yield of grain md/acre.	Seed rate per acre	Yield of grain md./acre.
12 in.	35·6	20 lb.	35·0	40 lb.	36·3
15 in.	35·5	40 lb.	36·0	60 lb.	35·5
18 in.	36·4	60 lb.	36·5	80 lb.	35·6
F' test	Not sig.		Not sig.		Not sig.
S.Em.	+0·59		+0·59		+0·59

The lowest delta (12 inch) gave almost as good yield as the highest. The increases in yield by increasing doses of nitrogen fall short of a significant level, apparently, because the general yield level of the crop under the experiment was very high, the mean yield being 35·8 md./acre. The lowest seed rate (40 lb./acre) proved the most economical as no increase in yield was recorded by increase in seed rates.

The effect of irrigation in relation to fertilizer application was also studied in another experiment on wheat, where soaking dose of water was not applied. The treatment consisted of irrigation frequency (2, 3, 4 irrigation), depth of irrigation (2, 3, 4 inch), nitrogen level (0, 30, 60 lb. N) and phosphate levels (0, 30, 60 lb| P_2O_5 acre). The yield results are given below:—

TABLE XIII

Effect of different levels of Irrigation in conjunction with N.P & K. doses on wheat.

Irrigation delta + 2·03″ rain.	Yield of grain md/acre	Yield of straw md/acre	Depth of Irrigation	Yield of grain md/acre	Yield of straw md/acre
8 in.	31·3	69·2	2 in.	32·9	72·9
11 in.	34·1	75·9	3 in.	33·3	77·2
14 in.	34·4	88·1	4 in.	34·5	83·0
Nitrogen level			Phosphate level		
0	32·6	73·9	0	31·6	73·8
30 lb. N	34·2	80·7	30 lb. P_2O_5	33·9	79·4
40 lb. N	34·0	78·6	60 ,,	35·3	80·0
S.Em.	±0·915	±1·58		±0·915	±1·51
C.D. at 5% level	2·61	4·5		2·61	4·58

The yield of grain as well as straw increased progressively with more frequent irrigations, the optimum delta being between 11 inch to 14 inch. Deeper irrigation tended to show higher yields but the increases were significantly marked only in straw weight. Application of 30 lb. P2O5 significantly increased both the grain and straw yields.

3. *Response of potatoes to delta and depth of irrigation and levels of nitrogen:*—

The effect of 3 levels of irrigations (20″, 28″, 36″ including rainfall), three depths of irrigation (2″, 3″ and 4″) and 3 levels of nitrogen (80, 120 and 160 lb. N/acre) were studied on potato crop.

TABLE XIV

Effect of different delta and depths of irrigation and nitrogen doses on potato.

	Treatments	Yield in mds/acre.	Evapo-transpiration ratio.
Delta of irrigation +1·32″ rain.	I_0—20 acre inches	293·0	795·0
	I_1—28 acre inches	299·0	1131·0

	Treatments	Yield in mds/acre	Evapo-transpiration ratio.
	I_2—36 acre inches .	325·0	1402·0
	'F' test	Significant	
	C.D. at 5%	28·7	
Nitrogen doses	N_0—80 lbs. .	293	1147
	N_1—120 lbs. .	311	1090
	N_2—160 lbs. .	313	1091
	'F' test	Not significant.	
	S.Em.	±9·81	
Depth of irrigation	D_0—2″ depth .	307	1085
	D_1—3″ depth .	315	1074
	D_2—9″ depth .	293	1178
	'F' test	Not sig.	Significant
	S.Em.	±9·81	—
	C.D. at 5%	..	115·75

The linear response to the delta of irrigation was significant. Deeper irrigation of four inches depth recorded lower yield than shallower irrigation although the differences were not significant. Increasing level of nitrogen tended to increase tuber out-turn. The treatment effects on potato yield was masked by the attack of late blight. Increasing the delta of irrigation increased the E.T.R. significantly. Other factors had little effect on evapo-transpiration ratio of the crop.

4. *Relative efficiency of nitrogen doses and method of irrigation on tobacco.*—The experiment involved 4 different soil moisture regimes, 5 levels of nitrogen and two methods of irrigation. The results are given below:—

TABLE XV

Effect of different soil-moisture tensions and methods of irrigation in conjunction with nitrogen doses on tobacco.

Treatments	Yield in mds/acre
Soil moisture Tensions	
T_1—0·20—0·30 atmosphere	18·39
T_2—0·30—0·50 ,, ...	22·16
T_3—0·50—0·70 ,, ...	20·23
T_4—above 0·85 ,, ...	18·07
'F' test	Significant
S.Em.	±0·5
C.D. 1 %	1·81
,, 5 %.	1·40
Nitrogen levels	
N_0—0.lb. N	13·00
N_1—40 lb. N	17·35
N_2—80 lb. N	20·84
N_3—120 lb. N	23·35
N_4—160 lb. N	23·95

Treatments.		Yield in mds./acre
	'F' test	Significant
	S.Em.	±0·64
	C.D. at 1%	2·6
	„ 5%	1·9
Methods of irrigation .	M_1—Furrow method . .	20·18
	M_2—Flat method . . .	19·23
	'F' test . .	Not significant
	S.Em. . . .	±0·40

Frequent irrigation at the lowest tension and delayed irrigation at the highest tension yielded significantly lower yield of tobacco leaf, than irrigations at medium tensions. Irrigations applied at 0·30 to 0·50 tension gave the highest yield. Increased doses of nitrogen increased the yield significantly. The increases followed the law of diminishing returns in as much as there was no significant difference between 120 and 160 lb. N/acre.

5. *Response of cotton to levels of irrigation, nitrogen doses and sowing dates.*—This was the second year of the experiment. The object was to study the inter-relationship of different delta of irrigation (16, 18 and 20 acre inches); nitrogen doses (12, 40 & 80 16/acre) and dates of sowing of cotton (1/5, 20/5, 16/6). 23.8 in. rain was received during the crop season. The main effects of irrigation and nitrogen did show significant differences in cotton yield. The delayed sowings reduced yield and the E.T. ratios of the crop.

V.—Weed Control Investigation Scheme

1. *Weed Control Experiments on Wheat.*—2,4-D application brought about marked reduction in the weed population in wheat. Hoeing and hand-weeding also showed lower weed population as compared to control. Three years cumulative effect of treatments on the yield of wheat showed that all the treatments (8 oz., 1 lb. post emergence; 8 oz., 1 lb. pre-emergence and 8 oz. pre-and 8 oz. post-emergence) increased significantly the wheat yield over control. The yield varied from 18·4 to 20·8 md./acre under different treatments as compared to 15·9 md./acre under control. On the basis of these results, 2,4-D at the rate of 1 lb. acid equivalent is being recommended for eradicating weeds in wheat in the Intensive Cultivation Scheme.

2. *Control of sorghum halepense by chemical and cultural methods.*—The treatments consisted of 2,4-D (O, 5 and 10 lb./acre); 2,4,5-T (O, 5 and 10 lb./acre); T.C.A. (O, 30 lb. and 60 lb./acre) and cultivation (1, 3 and 6). This was a confounded design experiment to contain all combinations of the various treatments.

TABLE XVI

Population of rhizomes and grain yield of wheat after weed control treatments

Treatment and dose		Effect on weeds			Effect on wheat yield.		
		Wt. of rhizomes per cu. ft. in gms	S.Em.	L.S.D.	Yield per acre in mds.	S.Em.	C.D. at 5%
2,4-D	0	97·1	±19·68	..	18·5	±0·54	1·556
	5 lb.	133·7			20·4		
	10 lb.	139·2			21·7		
T.C.A.	0	244·4	±19·68	56·7	14·9	±0·54	1·556
	30 lb.	99·5			22·2		
	60 lb.	26·2			23·5		
Cultivations	1	238·2	±19·68	56·7	16·3	±0·54	1·556
	3	110·4			17·6		
	6	21·5			26·7		

Interactions :—TCA+ Cultivation:

wt of *Baru* rhizomes in gms. per cu. ft.

Cultivations.	Rate of T.C.A. per acre		
	0	30 lb.	60 lb.
1	437·4	204·5	72·7
2	231·2	94·0	5·9
3	64·6	0·0	0·0
S.Em.		±34·09	
C.D. at 5%		98·204	

Chemical weedicide T.C.A. and cultivations brought about highly significant reduction in the stand of *Baru*. The interaction obtained between T.C.A. and cultivations was significant at 1 per cent level of significance T.C.A. in combination with 6 cultivations caused complete eradication of *Baru*. The application of weedicides and eradication by cultivation significantly increased the yield of wheat grain over control treatment.

3. *Control of weeds in sugarcane.*—Broad-leaved weeds and *Cyperus rotundus* compete with sugarcane for space, plant nutrients and soil moisture. Spraying of 2,4-D at 2 lb./acre as pre and post-emergence weedicide alone and in combination with hoeing controlled the weeds better than the treatment of hoeings alone. The combination of herbicide and hoeing gave highest yield of 886·2 md./acre of stripped cane as compared to 635·2 md./acre under control. Individual treatments manifested their effect in increasing the cane out-turn, in most cases, significantly over the control treatment.

4. *Control of weeds in potato by chemical and cultural practices.*—Two years' cumulative effect of treatments (2,4-D, M.C.P.A. at 0.6 and 1.2 oz./acre and cultural practices) indicated that weed population was significantly reduced as compared to control. A highly significant interaction was obtained between 2,4-D and M.C.P.A. and the response due to two chemicals was very much additive. The effect of treatments or

potato was vitiated due to late blight attack. M.C.P.A. treatment significantly increased the yield by 26 md. per acre.

5. *Effect of various weedicides on weeds in cotton.*—This was the second year of the experiment. Effect of 3 levels (6, 12 and 18 lb./acre) of T.C.A. and P.C.P. as pre and post-emergence syrays; 4 levels of 2,4-D (4, 6, 8 and 10 oz/acre) as pre-emergence spray, hand weeding and hoeing with bullock and the combinations of T.C.A., and P.C.P. with hoeing was studied on weed control in cotton crop and their influence on seed cotton yield. Pre-emergence application of T. C. A. at all the 4 levels significantly reduced the population of annual grasses. P. C. P. had no effect on grasses. The cultural treatments proved better than chemical treatments in effectively controlling weeds in cotton and in increasing its yield.

6. *Control of weeds in peas crop by weedicides and inter-cultivations.*—In the second year of the experiment confirmatory results were obtained:—

TABLE XVII

Effect of weedicides and inter-cultivations on the yield of peas grain.

Treatment	Application Rate—12 oz. acre.	Mean no. of weeds per sq. ft.	Mean yield per acre in mds.
Pre-emergence	2, 4-D Sodium salt	98	23·5
	2, 4-D Butoxyethyl ester	90	24·6
	MCPA	80	23·2
	MCPB	98	22·9
Post-emergence	2, 4-D Sodium salt	21	16·1
	2, 4-D Butoxyethyl ester	26	15·8
	MCPA	23	21·4
	MCPB	27	40·2
Do.	Bullock Hoeing	103	24·1
	Hand Weeding	42	40·8
	Control	125	19·4
	S.Em.	..	± 1·79
	C.D. at 5%	..	5·2

Control of weeds and improvement in the yield of peas. Number of weeds due to hand hoeings and post-emergence treatment of herbicides was comparatively very low. Post-emergence application of M.C.P.B. at the rate of the acid equivalent gave an out-turn of 40·2 md. which equal to the yield in the treatment of hand weeding.

VI.—Agricultural Extension Scheme

(a) *Training and investigations.*—Eight agricultural extension students of the second year submitted their thesis and were declared successful. Extension studies indicated that for introducing manures and fertilizers the percentage of success was the highest with result demonstration, but the cost of bringing about improvement is the highest. The lowest cost for introducing fertilizer was through leaflets and farm bulletins. The highest percentage of seed saturation was 47·8 per cent. for all crops in village Tilangpur Kotla and of wheat 79·0 per cent. in Gheora village. Cultivators owning more than 25 acres had adopted N.P. 718 wheat to the largest extent but their percentage adoption for vegetables was the least. The cultivators of larger sized holdings were more influenced by result demonstration and least by other methods. On the other hand, cultivators owning small sized holdings were most influenced by a combination of result demonstration and neighbour influences. 75 per cent. of the

farmers had favourable opinion about the activities of Intensive Cultivation Scheme. The adoption of improved practices was closely related to education, intensity of demonstrations and contact with agricultural workers in different villages. There has been gradual development of improved agricultural practices. The success achieved by October, 1957 was 52·68 per cent. of 10 years target fixed upto 1960-61.

In Community Development activities, there is greater participation in labour of cultivators and in cash of non-cultivators. Maximum rural development had taken place in Nilouthi village, calculated on the basis of agricultural and other development activities.

Eight post-graduate students admitted in the Agricultural Extension course in 1957 started their investigations on various research problems from October, 1957.

(b) *Intensive Cultivation Scheme.*—Programme of improving agricultural practices was combined under the Intensive Cultivation Scheme. Wheat variety N.P. 718 saturated an area of 4,061 acre which accounts for about 72 per cent. of total area under wheat during 1957-58. Delhi State Department of Agriculture had purchased 550 mds. of seed of wheat N.P. 718 from cultivators of the Scheme area by 30th June, 1958.

Results of crop-cutting experiments indicates that *Bajra* T. 55 over-yielded the local variety by 0·92 mds./acre which increase was significant at 1 per cent. level. Ammonium sulphate, chilean nitrate and urea at 20 lb. N applied to wheat showed no differential effect. The increase in yield due to 20 lb. N dose over the control was 3·49 mds. per acre.

(c) *Key Village Scheme.*—Natural services given to cows and buffaloes were 94 and 379 respectively. Most of the animals had conceived. 31 buffaloes were artificially inseminated. 17 animals were treated for sterility. The male calves below 2 year castrated were 120 bull calves and 106 buffaloe bulls. Total number of preventive inoculations given were 7,613. The cow bull K.V.S. 1 of Nangloi was awarded first prize in the State Cattle Show and buffaloe bull K.V.S. 8 the second prize in the show. The work on fodder development was initiated.

VII.—Plant Tissue & Spray Fertilization Scheme

1. *Response of jowar to application of urea through sprays and in soil.*—The scheme was started late in the year and only two experiments were conducted.

This experiment was conducted to compare the efficiency of urea applied to soil and foliar spray at concentration of 4 and 8 per cent. at 40 and 80 lb. N levels. Plant tissue tests on the crop indicated that N uptake was higher at 80 lb. N dose than at 40 lb. and control. Spray treatments gave lower nitrate test than soil application. There was no significant difference on *jowar* yield in response to various treatments.

2. *Foliar spray fertilizer application experiment on tomatoes.*—A foliar spray fertilization experiment on improved Meeruti variety was conducted during *rabi* 1957-58.

TABLE XVIII

Effect of spray and soil fertilizer application on tomato.

Treatments	Yield in mds/acre
1. A-NoPo (control)	167·47
2. B-30 lb. N/acre Soil application	257·27
3. C-60 " " "	340·83

	Treatments	Yield in mds/acre
4.	D-120 lb. N/acre	386·51
5.	E-20 lb. P_2O_5	226·03
6.	F-40 lb. „	207·18
7.	G-30 lb. N/acre +20 lb. P_2O_5 Soil application	234·63
8.	H-30 lb. „ +40 lb. „ „ .	209·42
9.	I-60 lb. „ +20 lb. „ „ .	309·51
10.	J-60 lb. „ +40 lb. „ „ .	382·29
11.	K-120 lb. „ +20 lb. „ „ .	396·79
12.	L-120 lb. „ +40 lb. „ „ .	413·54
13.	M-30 lb. N/acre 2% spray	318·42
14.	N-60 lb. „ „	251·57
15.	O-30 lb. „ 4% spray	309·17
16.	P-60 lb. „ „	347·58
17.	Q-20 lb. P_2O_5 2% spray	220·06
18.	R-40 lb. „ „	211·9
19.	S-30 lb. N/acre + 20 lb. P_2O_5/acre 4% spray	276·17
20.	T-30 lb. „ + 40 lb. „ „ .	358·11
21.	U-60 lb. „ + 20 .b. „ „ .	315·60
22.	V-60 lb. „ + 40 lb. „ „ .	289·91
	S.Em. . .	+37·97
	'F' test . .	Sig. at 1% level
	C.D. at 1% . .	145·52 md/acre.
	„ 5% . .	108·47 „

Highest yield (413·5 md./acre) was obtained when 120 lb N + 40 lb. P_2O_5 was applied to the soil. Urea applied at 30 and 60 lb. N rate as foliar spray in concentration of 2 per cent. and 4 per cent. respectively proved superior to application of these nitrogen doses to the soil. Application of phosphate as foliar spray conduced to early maturity of fruits.

VIII.—Agricultural Economics Section

(a) *Operational and working cost studies on Tractors.*—Studies on working costs of various makes of tractors were completed from 1953-54 and 1954-55. These are presented in Table No. 1 below. Costs for 1955-56 are being worked out.

TABLE XIX

Costs of operations by Tractors, 1953-54 and 1954-55

Tractor	Cost per hour (in Rs.)						Cost per acre (in Rs.)					
	Ploughing		Discing		Grubbing		Ploughing		Discing		Grubbing	
	1953-54	1954-55	1953-54	1954-55	1953-54	1954-55	1953-54	1954-55	1953-54	1954-55	1953-54	1954-55
D-4 (I)	7·25	No op.	7·50	8·35	7·08	8·16	14·80	No op.	4·87	6·19	11·42	7·77
D-4 (II)	5·36	6·61	5·40	5·52	5·34	5·10	9·92	8·37	3·46	3·54	6·94	5·10
D-4 (III)	7·55	6·67	7·66	6·66	7·22	6·27	13·73	13·08	7·74	4·96	6·94	9·95

The D-4 (III) tractor has shown a decided trend in economising costs during 1954-55 over 1953-54, although these are higher than the costs with D-4 (II).

The number of hours worked by various makes of tractors and the output per hour were computed and compared for the years 1953-54, 1954-55 and 1955-56. This information is presented in the following table :—

TABLE XX

Output of Tractors 1953-54 to 1955-56

Tractor	Total working hrs. (Including road & idle work)			Average Acreage per hour of work								
				Ploughing			Discing			Grubbing		
	1953-54	1954-55	1955-56	1953-54	1954-55	1955-56	1953-54	1954-55	1955-56	1953-54	1954-55	1955-56
D4 (I)	137·50	127·50	nil	0·56	No op.	..	1·91	1·60	..	0·76	1·29	.
D4 (II)	601·50	182.50	nil	0·71	0·85	..	2·01	1·96	..	1·50	1·17	..
D4 (III)	174·25	202.92	354·0	0·72	0·64	0·73	1·33	1·71	2·0	1·60	0·80	1·37
T.D.—9	3·50	275·25	930·25	No op.	0·69	0·75	1·25	1·65	2·32	No op.	1·37	2·05
M.H. Combine.	..	..	160·0	..	..	..	..	..	..	..	..	..
Russian	.	..	..	32·0	..	..	0·80	..	..	..	..	..	..
Farmall	.	..	58·25	..	..	No op.	..	..	1·62	..	..	1·92	..
	916·75	824·42	1476·25									

Figures regarding total number of hours worked show a slight decline in mechanisation during 1954-55 with a substantial increase over 1953-54 in 1955-56. Clear trends regarding operational efficiency were noticed only in the case of discing with D4 (III) and T.D. 9 tractors; indicating a progressive increase in per hour output over the three-year period.

(b) *Survey for Land Transformation studies in Social Welfare Centres.*—In the concluding round of preliminary surveys conducted at the Social Welfare Centre, Fatehpur, the following conclusions emanated:—

(i) In matters of diet and requirements for balanced consumptions, the area was found to be deficit in cereals, fats, oils and vegetables. It was surplus in sugar, milk and fruits. Fodder and concentrates for cattle were also in short production.

(ii) 42·6 per cent. of the total population comprised landless labour which require alternate means of employment.

(iii) The Chief industry of the tract is cattle raising and milk production.

In view of these, the Social Welfare Centre was advised to concentrate their work on these aspects.

(c) *Farm Planning and Budgeting Studies.*—A plan has been prepared to conduct farm planning and budgeting of investigations on individual holdings of cultivators in eight villages of the Intensive Cultivation Block. Budget estimates of probable expenses and receipts have been prepared for this experimental groups. An equal number of holdings of similar size in each village have been selected at random to serve as control. The actual costs of operations and returns will be studied in both the experimental and control group of holdings.

This project is expected to stimulate the entrepreneurial abilities of the farmers.

IX.—Co-ordinated Schemes of Fertilizer Trials in Cultivators' Fields (I.C.A.R.)

Under Model Agronomic Experiment Scheme of I.C.A.R., 33 centres were working, out of which two centres located in Bihar were selected and approved by the Sub-Committee on Fertilizer Trials in April, 1958. 169 experiments were conducted during *kharif* and *rabi* seasons at 31 centres on paddy, wheat, *jowar*, cotton, groundnut and *kharif* legumes. The data of most of these experiments has been received by the Statistical Wing of I.C.A.R. for analysis and the results will be reported next year.

Under the Co-ordinated Scheme of Simple Trials in Cultivators' fields, the financial sanction was issued by I.C.A.R. for 50 districts in 14 States on 1st July, 1957. Out of 14 States, in seven, namely, Delhi, Himachal Pradesh, Kerala, Madhya Pradesh, Orissa, Rajasthan and the Punjab, a part of the field staff consisting of field Assistants and Supervisors were appointed during 1957. They conducted 843 experiments. The results of these experiments are being analysed and will be reported next year. Three States, namely, Orissa, Bihar and Mysore have appointed the staff very recently. In the remaining States, namely, Andhra Pradesh, Bombay, Madras, Uttar Pradesh and West Bengal, the Scheme has been accepted by the State Governments and included in the State Plans.

Training of the field staff has been completed for Himachal Pradesh, Rajasthan, Bihar, Orissa, Mysore and Kerala States.

The consolidated report of wheat experiments conducted from 1953-54 to 1955-56 under Indo-U.S. Fertilizer Use Project was finalised. During the three years' period 136 complex experiments on eight 15-acre blocks and 2,705 simple trials in cultivators' fields were conducted in eleven Community Projects on wheat. The mean response was 2·9 and 4·4 md. to 20 and 40 lb. N/acre. Similar doses to nitrogen gave the responses of 3·0 and 4·7 mds. of wheat in simple fertilizer trials. Application of 20 and 40 lb. $P_2 O_5$ per acre gave the response of 1·7 and 3·0 mds. in complex experiments and 2·3 and 3·3 mds. in simple trials. The responses to phosphorus was high at Bhagwai in Madhya Pradesh, and was good at Pura (Kanpur) in U.P. The average differences in responses to ammonium sulphate, urea, ammonium nitrate, ammonium sulphate nitrate and ammonium chloride were small.

X.—Agronomic Experiments at Pusa

(i) *Permanent manurial and rotation experiments.*—Maize yield was higher from plots manured with organic manures (F.Y.M. or F.Y.M. and rape cake) than N.P.K. applied as fertilizers. In case of wheat, highest yield was obtained by the treatment green manure super phosphate followed by F.Y.M. and N.P.K.

(ii) *New Manurial experiments.*—F.Y.M. at 8,000 lb./acre gave highest yield (15·8 md./acre) of maize. Rape cake, N.P.K., N.P. and N treatments were next in order of merit. Similar results were obtained with peas crop.

XI.—Cattle Breeding and Management

(i) *General.*—The strength of the Sahiwal herd on June 30, 1958 was 79. The herd consisted of 36 cows, 3 stud bulls, 14 young male stock; 18 young female stock, 5 male calves and 3 female calves.

(ii) *Milk yield.*—The wet and overall average for 1957-58 were 21·8 and 12·3 lb. respectively as against 21·4 and 15·0 lb. recorded last year. 26 cows completed their lactation during the year. One of them yielded over 10,000, four over 8,000, and three over 7,000 during the lactation period. The average total yield per day was 463·8 lb. The herd average was 6,175·4 per lactation.

(iii) *Calf rearing.*—31 calves were born during the year and 22 were transferred to young stock. The calves were fed standardized milk (3·5 per cent. fat) upto the age of one month and then for next 5 months in case of males and 8 months in females were put on skim milk ration. Such calves showed normal growth under the two systems of feeding. A saving of about 46 per cent. in cost of rearing was effected by skim milk feeding.

(iv) *Early maturity experiments.*—Early matured heifers yielded 5,800·6 lb. on an average in the first lactation as against 4,622·8 lb. for the second lactation and 6,921·4 lb. for the adults. Average age at first calving was 2 years 6 months and 2 days.

(v) *Sale of cattle.*—Eleven young bulls were sold to 4 parties at a total price of Rs. 8,050/-.

XI.—Programme of Work for 1958-59

1. *Soil Fertility Section:*—

(i) Building up of soil fertility through organic manures and inorganic fertilizers.

(ii) Building up of soil fertility through phosphate manuring of legumes.

(iii) Building up of soil fertility through crop rotations combined with manures and fertilizers.

(iv) Experiments on mixed-farmed 6-acre holdings.

2. *Field Crop Section:*—

(i) Response to manures and fertilizers.

(ii) Cultural experiments.

(iii) Varietal trials

(iv) Agronomic experiments on grasses and legumes for pasture management.

(v) Grassland Scheme (I.C.A.R.)

3. *Vegetable and Commercial Crop Section:*—

(i) Response to manures and fertilizers.

(ii) Cultural experiments.

(iii) Varietal trials.

(iv) Vegetable growers' 3-acre holdings.

4. *Farm, Cattle and Development Section:*—

(i) Line breeding and selection for improvement in milk yield.

(ii) Feeding of stock on balanced ration for optimum growth.

(iii) Rearing of pailfed calves on skim milk.

(iv) Mixed Farming experiment.

(v) Intensive Cultivation Scheme and Key Village Scheme.

5. *Project under Second Five Year Plan:*—

(i) Irrigation Investigation Scheme.

(ii) Weed Control Investigation Scheme.

(iii) Agricultural Extension Scheme.

(iv) Plant tissue tests and spray fertilization Scheme.

6. *Agronomic Experiments at B.S.S. Pusa:*—

(i) Permanent manurial and rotation experiment.

(ii) New Manurial experiment.

7. *Agricultural Economics:*—

(i) Farm management studies.

(ii) Alternate budgeting and planning.

(iii) Land Transformation.

ANNUAL SCIENTIFIC REPORT OF THE AGRICULTURAL RESEARCH SUBSTATION, KARNAL FOR THE YEAR ENDING JUNE 30. 1958.

1. *General.*—The total area of the Substation situated in block Nos. G.A., 2, 3 and 6 is 305·08 acres. *Kharif* and *rabi* crops occupied 193·71 and 228·20 acres respectively.

The main activities of the Agricultural Research Substation consisted of (i) carrying out large scale field experiments on different agronomic factors of production; (ii) multiply and distribute seeds of improved strains of field crops and (iii) render assistance to different Divisions of the Institute to carry out their field experiments.

2. *Response of crops to weather.*—The monsoon set in by the 22nd July, 1957 which delayed transplanting of paddy and sowing of other *Kharif* crops. The total precipitation received during the year was 69·01 cms as against 121:31 cms, 94:23 cms and 71:98 cms recorded during the corresponding periods of 1956-57, 1955-56 and 1954-55 respectively. The rainfall during the year was slightly more than the normal 65:72 cms but the distribution was rather erratic.

Second fortnight of September remained dry which had an adverse effect on late paddy. The soil moisture for *rabi* sowings in *barani* plots could not be adequately preserved. The cooler and humid weather during the month of April delayed the harvesting and threshing of *rabi* crops to some extent. There was no serious attack of any disease or insect pest. Periodic dusting and spraying operations were carried out on prophylactic measure.

3. *Crop yields.*—The yield of the principal crops grown on the farm during the year together with those of previous are given below:

TABLE XXI

Average out-turn of crops

	1955-56		1956-57		1957-58	
	Area	Yield/acre	Area	Yield/acre	Area	Yield/acre
	acre	md.	acre.	md.	acre.	md.
Paddy	27·27	16·7	35·94	32·01	36·43	19·23
Cotton	6·00	17·6	13·15	10·83	18·72	6·77
Wheat	120·09	10·5	138·47	20·25	137·15	17·10
Oats	14·30	16·2	5·00	21·97	10·61	19·10
Gram	18·90	6·3	11·13	20·16	27·65	11·03
Peas	13·70	8·3	4·5	23·37	8·66	7·36
Maize	16·91	4·2	17·4	11·66	11·35	12·02
Bresseem . . .	5·00	430·0	1·63	244·46	7·75	375·67

The drop in production is accounted for by shortage of irrigation and failure of winter rains than due to depletion of fertility as proper manuring schedule was practised during the year.

Research Projects:

A. Manurial Experiments

Fertilizer placement experiment on cotton.—This is the first year of the experiment. Two types of phosphate, super-phosphate and ammonium phosphate, at two levels of 20 lbs. P_2O_5 and 40 lbs. P_2O_5 were placed by three methods, namely, (i) Broadcast, (ii) 2·5″ below seed, and (iii) Band placement for cotton 216 F/14 along with a basal dressing of nitrogen at 50 lb. N/acre. The effect of levels of phosphate was not significant. There is no significant difference between the yield due to the two sources of phosphate. The placement methods did not prove superior to broadcast system.

Interrelationship of sowing dates, different spacings and levels of nitrogen on paddy crop:

Two transplanting dates, five spacings and three levels of nitrogen were compared in this experiment with the following results:

Table XXII

Effect of different sowing dates, spacings and levels of nitrogen on paddy.

Mean yield of paddy md./acre

Date of transplanting	Levels of nitrogen lb./acre			Mean	S. Em.	C.D. at 1%
	0	30	60			
5th July . . .	13·4	15·6	15·6	14·9	±0·42	1·57
20th July . . .	13·9	21·4	18·2	17·8		
Mean	13·6	18·5	16·9	16·3	Interaction N × D 'F' test—significant	
S. Em.		±0·51			S.Em.	±0·73
C. D. t 5% . . .		1·45			C.D. at 5%	2·05

The crop in 60 lb. N dose treatment lodged. Therefore 40 lb. N dose gave the highest average yield of 18·5 md. which is significantly greater than control. Transplanting on 20th July gave higher yield than the crop transplanted on 5th July. The differential response to spacings was not significant. The interaction between levels of nitrogen and dates of transplanting proved to be significant.

Response to levels of nitrogen and phosphate in relation different spacings and dates of sowing on maize:

This was the first year of the experiment.

TABLE XXIII

Effect of different levels of nitrogen and phosphate, spacings and dates of sowing on maize.

Maize yield in mds./acre

Nitrogen levels lb./acre.	Spacings between and within rows 24″×9″	24″×12″	30″×12″	Dates of sowing 15th June	1st July	Mean	S.Em.	C.D. at 5%
0	11·2	11·6	11·1	9·8	12·8	11·3		
30	17·6	16·0	17·5	15·3	18·7	17·0	+0·34	0·96
60	24·4	19·9	20·9	20·2	23·1	21·7		
Mean	17·7	16·4	15·8	15·1	18·2	16·7	'F' test sig for Interaction spacing × nitrogen levels.	
S.Em.		±1·15			±0·94			
'F' test		—			—			
C.D. at 5%	Not significant				Significant 2·97		S.Em.	±0·59
							C.D. at 5%	1·66

Spacings effects were not significant. 1st July sowing proved significantly superior to 15th June sowing. 60 lb. N was significantly superior to 30 lb. N. which in turn was significantly superior to control (11·29 mds/acre). Interaction between nitrogen levels x spacings was significant. 60 lb. N. dose with 2·0′×9″ spacing produced the highest yield of 24·4 md./acre.

B. VARIETAL TRIALS

Varietal trials of fine and medium fine type of paddy (1954-55):—

Thirteen varieties of paddy, namely, N.P. 125, N.P. 130, N.P. 137, Palman 34-22, Palman 246, Begmi 290, Begmi 292-19, Basmati 370, T9, T21, T138, Sonpattar 4-12-19 and Sonapatter 7-2-5, were tested for their yield. The varietal differences were significant. Variety T21 produced the highest yield of 34·99 md./acre. Thus variety N.P. 137, a fine type showed as good performance as the other varieties of the same kind. Palmans were found to be significantly superior to N.P. 130 the standard variety.

Varietal trial of coarse and medium coarse types of paddy (1954-55):—

The types included in this trial were Jhona 349, Jhona Kesarwala S.20, Jhona Kesarwala 269, CH 10, 41, 42, 43, 53, 63, EK 70, Z. 31, N.P. 97, and T43, for their yield performance under Karnal conditions for selecting best variety for the tract. The varietal differences were significant. Among the coarse varieties, the standard Jhona 349 produced the highest yield of 32.86 mds. acre. All the other varieties were significantly superior to Ch 10 which gave yield of 21·5 mds. only.

Among the medium coarse varieties E.K. 70, produced the highest yield (29.33 mds. acre) and was significantly superior to N.P. 97 (23′51 mds./acre) and T43 21.54 mds. acre).

C. Cultural Experiments

Village of wheat in conjunction with manures and fertilizers :—In the second year of the experiment the preparatory tillage treatment manifested small difference in acre yields.

Table XXIV

Effect of Tillage in conjunction with different fertilizers on Wheat.

Basal treatment	Green matter added md./acre	Tillage treatment	Grain yield md./acre.
1. Green Manure + 60 lb. P_2O_5	284·1	Tractor ploughing, discing and grubbing.	21·0
2. G.M. alone	256·3	Victory ploughing and country plough cultivation.	20·3
		Country plough cultivation .	19·5
S.Em.	±5·24	S.Em.	±0·57
C.D. at 1%	23·02	'F' test	Not significant.

The basal treatment showed significant difference in green matter added to the soil. Application of 60 lbs. P_2O_5 conduced to addition of 28 mds. more of green matter to the soil. It also mobilised phosphate for the succeeding crop as evident from the following results:—

Table XXV

Effect of basal and top dressing treatment on yield of wheat.

Particulars	Control	Basal dressing 60 lb. N.			Top dressing 30 lb. N			Top dressing 30 lb. P_2O_5				
		Basal dressing						Basal dressing				
		FYM 30 lb. N	G.M.	A/S 30 lb. P_2O_5	FYM 30 lb. N	G.M.	Nil	FYM 30 lb. N	FYM 30 lb. N + A/S 30 lb. N	G.M. 60 lb. N	A/S 30 lb. N	Nil
Yield in mds./ acre.	12·0	16·1	19·0	19·3	22·9	21·3	25·6	18·4	17·2	24·0	22·1	25·4	18·5	23·7

All manurial treatment were significantly superior to control. Application of phosphate at the rate of 30 lb. P_2O_5 enhanced the yield from all sources of nitrogen applied as basal treatments. But top dressing with nitrogen was still better than top dressing with 30 lb. P_2O_5.

Paddy rotational experiment.—The treatments consisted of four rotations, namely, *paddy-wheat-cowpea-wheat* (A); *paddy-berseem-paddy wheat* (B); *paddy-gram-paddy-wheat* (C) and *paddy-wheat-paddy-wheat* (D). The rotational effects were significant. The rotation B on the whole gave maximum return per acre.

D. Cultivator's Holdings

Four 6=acre holdings were laid out in block Nos. 3 and 6 in *rabi* 1955-56. The yields in the three holdings with recommended improved rotations, cultural and manurial practices were definitely higher than the holding with local practices. The effect of phosphate manuring of legume and direct application of nitrogen to cereals in building up soil fertility was indicated by yields of crops in different holdings. Best yields were obtained in holding No. 4 which has less intensity of croping but the total production was less due to less area under the crop.

Work of other Divisions:—

Botany Division.—The experiments conducted were:

(i) Wheat varietal trial under *barani* and irrigated conditions; (ii) Wheat Bunt Control experiment; (iii) Wheat varietal trial under different fertility levels; (iv) Hybrid maize production on an acre of about 20.0 acre.

Mycology Division:—

(i) Study of diseases in different varieties of sugarcane.

Entomology Division :—

(i) Biological control experiments on cotton insect; (ii) Biological control experiment on maize stem borer; (iii) Control schedule of cotton pests.

Seed supply.—The seed supply chiefly consisted of 1,906 mds. of rust resistant varieties of wheat; 56·6 md. of paddy, 88 mds. of maize; 55 mds. of gram and 51·5 mds. of peas. The demand for other seeds was small. The quantity of wheat seed distributed was almost double of that in 1956-57.

Research Programme for 1958-59

1. Conduct manurial trials with paddy, wheat, maize, cotton, legumes and vegetables.
2. Tillage experiments with wheat.
3. Rotation experiments with paddy.
4. Cultural experiments with cereals and cash crops.
5. Varietal trials with wheat, paddy and linseed.
6. Cultivators mixed farmed holdings.
7. Large scale field experiments of the various Divisions at the Institute.

Annual Report of the Statistics Section for the year ending 30th June, 1958.

A. Advisory and Training:

The field experiments were designed and the laboratory and field data were analysed for the various Divisions of the Institute. Besides, training in Agricultural Statistics was imparted to the P.G. students of the Institute, C.C.A. students and the short-course students deputed by the Director, Soil Conservation, Research and Demonstration, Ministry of Food and Agriculture. The students and research staff of the Institute were advised pertaining to designing of experiments, the analysis and interpretation of the data of their research problems.

B. Research Projects:

General aspects of milk improvements in Sahiwal Herd:

The data on Sahiwal herd, accumulated over half a century were examined for (i) heritability (ii) growth rate of calves fed on skim milk ration, (iii) persistency in milk yield, and (v) prediction of lactation yields of cows. The results obtained under each head are summarised separately:—

(i) *Heritability.*—The intra-sire heritability for the Cello (starting bull) line used for breeding purposes was found to be significant at 10 per cent. with heritability co-efficient of 43 per cent. This indicates that there are good prospects of improving milk yield through a suitable breeding policy.

(ii) *Growth rate of calves.*—Quadratic exponential growth curves were fitted to the weekly weights of calves fed on (i) standard milk, and (ii) milk and their growth rates was compared. The two set of calves of same age and birth weights did not differ significantly.

(iii) *Persistency in milk yield.*—Persistency in milk yield of the herd was further studied in relation to (i). Total lactation yield, and (ii) initial 8 week's yield. The correlation co-efficients for these factors were highly significant. The regression of persistency on total lactation yield indicated a rise in persistency in relation to an increase in the yield and high milk yielding cows were found to be significantly more persistent than the low yielders.

The persistency decreases with age; but it is not influenced by the variation in season.

(iv) *Prediction of lactation yield.*—To obtain an estimate of the total lactation yield from the yield of earlier few weeks, the total lactation yield was correlated with 4, 6 and 8 weeks yield and also with yield up to date of service. It was found that 8 week's yield (the period when the yield rate reaches a maximum) was the best to predict the total yield. Next, the high genetical correlation between the yield for this period and the total lactation yield indicated that selection on the basis of initial yield would be reliable index.

2. *Analysis of Water Table Records* (1940-54):

Serial analyses of the water level records of the thirteen wells situated in the institute, Farm fields, recorded on 1st and 16th of each month were completed and a report on the results obtained was drawn up. The statistical analysis indicated differences among the overall average water

levels of the wells. The water level of most of the wells situated in the Main block and in the Division of Botany were comparatively high. There was no difference in the order of significance in the water levels of the wells on 1st and 16th of each month. The levels of the wells were high during the months of September, October, November and December and were low in the months of May, June and July. The water levels during the starting year (1940) was low in all the months, but it gradually began to rise until water table stablized in 1948.

3. *Sampling Methods for Growth Characters and yield of Crops*:

(a) *Sampling for maize yields.*—10 and 20 per cent samples were taken from the 72 plots of the experiment "control of weeds in maize by cultural and chemical method *kharif* 1957" to estimate the per plot yield. The grain yield as well as the ratio of grain to the total produce were statistically analysed separately in each sampling unit. The percentage S.Es., using the sample grain yields; varied from 12·21 to 10·96 and from 15·79 to 13·29 in case of 20 and 10 per cent. units of sampling respectively, for one to four samples of each kind.

For the ratio estimates, the percentage S.Es. varied from 2·74 to 1·38 for 20 per cent unit of sampling and 4·10 to 2·05 for 10 per cent unit of sampling, for one to four samples of each kind. Thus the percentage S.Es. in respect of the ratio estimate for both the units of sampling are appreciably lower than those of the sample grain yield estimate. The ratio method seems to be more reliable. Although, this years' results show a slight improvement with 20 per cent sampling unit over the 10 per cent sampling unit, using the ratio estimate, the 10 per cent sample taken twice has indicated consistent values of percentage S.Es. for the last two years. The 10 per cent unit may, therefore, be considered as a suitable sampling unit to estimate plot yields.

(b) *Sampling for grain yield, plant height and total stalk weight in jowar.*—Two samples, each consisting of 7 plants, were taken at random from each plot in two replications of the experiment "Response of jowar to the application of various levels of urea—*kharif* 1957" for studing the relationship between these factors.

Combining the data for the two samples, the relationship between the yield and the other two characters was studied on the basis of the average of 14 plants. The statistical analysis did not indicate significant treatment differences for any of the characters. However, the correlation between (i) grain yield and average height of the plants, and (ii) grain yield and total stalk weight were found to be significant.

Next, the data were analysed to determine the suitable sampling unit. The percentage standard errors in respect of grain yield and ratio of grain to total stalk weight were high, ranging from 19·1 to 10·6 and 14·3 to 12·1 respectively, for one to four samples each of 7 plants lower percentage S.Es. were, however, obtained in estimating plant height the order in this case being 7·0 to 5·3 per cent. From these results it could be said that a sample of 7 plants taken twice would be suitable for height estimation with 6 per cent S.Es. For other characters the percentage S.Es. being very high, no useful conclusion could be drawn .

(c) *Sampling for wheat yields.*—Sixty random samples, two from each plot and based on 10 and 20 per cent of the total produce, were taken from the experiment "Building up of soil fertility with cereal rotation series VI", with wheat (*Rabi* 1957-58) to determine a suitable sampling unit for the estimation of grain yield.

The sample grain yields as well as the ratio of grain to total produce were statistically analysed. With regard to sample grain yields the percentage standard errors were found to vary from 17 to 22 per cent for the two types of sampling and one to four samples of each kind. For the ratio estimates, the percentage standard errors varied from 7·6 to 8·7 per cent for 10 per cent unit of sampling and from 6·7 to 7·4 per cent for the 20 per cent unit of sampling for one to four samples of each kind. In view of the high percentage errors obtained above, none of the two sampling procedures appears to be suitable for the estimation of treatment mean yields.

4. *Crop-cutting Experiments in the village under the I.A.R.I.*:

Intensive Cultivation Scheme.—This year the crop cutting experiments in the villages under the I.A.R.I. Intensive Cultivation Scheme were carried out in the month of October and November, 1957 to study (i) the relative performance of the improved variety of *bajra* T.55 against the local variety in the demonstration plots, and (ii) the response of *bajra* crop to the fertilizers.

From the demonstration plots, the average yields of *bajra* T.55 and the local variety were 7·02 and 6·10 mds. per acre respectively. The difference of 0·92 mds. per acre *i.e.* 15·1 per cent between these varieties was significant at 1 per cent level of significance.

Every fertilizer treatment differed significantly at 5 per cent from the control while the differences among them were not significant. The average responses to the three nitrogen fertilizers, Amm. sulphate, chilean nitrate and urea, each at 20 lb. N per acre were 3·49, 3·36 and 2·78 md. per acre respectively.

5. *Statistical Analysis of data from different Divisions*:

The data on manurial experiments conducted at I.A.R.I., New Delhi from 1936-37 to 1956-57 *i.e.* for the period of 20 years were collected and statistically examined for (i) berseem, (ii) sugarcane, (iii) oil seeds, (iv) maize, and (v) wheat crops. The reports on the 1st four crops were drawn up. Further work is in progress.

Data from 32 chilean nitrate trials conducted in M.P. in the year 1953-54 and 1954-55, on behalf of the Agronomy Division and of ten other misc. experiments conducted in the Division were statistically analysed. In addition (i) data from the five progeny row trials in balanced and partially balanced lattices of Botany Division, (ii) data on Hortico Soil Testing kit and chemical composition of wheat grown at B.S.S., Pusa and at I.A.R.I., New Delhi of Chemistry Division, (iii) data from Entomology Division (on control schedule of mustard aphid, and pests in maize and cotton, and (iv) data on three fertilizer experiments from A. R. S. Karnal were statistically analysed and the results were reported to the respective Divisions.

REPORT OF THE DIVISION OF BOTANY

(Dr. S. M. Sikka)

The research work in this Division, which aims at the evolution of superior varieties of crop plants through fundamental and applied investigations in cognate disciplines of agricultural botany, namely, plant breeding, genetics and cytology, and plant physiology, continued to progress under its four main Sections—Plant Breeding and Genetics, Cytology and Cytogenetics, Crop Physiology, and Plant Introduction and Exploration. A special feature of the year under report includes the strengthening of work on hybrid maize under a co-ordinated all-India project financed by the Indian Council of Agricultural Research, with the active participation of the Rockefeller Foundation. In collaboration with the Foundation, a programme of work on millets has also been initiated. Steps have been taken to instal a 200-curie field device for gamma-irradiation, using Cobalt-60. This field irradiation unit, expected to be received shortly from Canada, is likely to start functioning by the close of the year 1958 and it would be the only one of its kind in Asia. Under the Project for the Intensification of Regional Research on Cotton, Oilseeds and Millets, sponsored jointly by the Indian Council of Agricultural Research, the Indian Central Cotton Committee and the Indian Central Oilseeds Committee, a regional station is to be located in this Division for cytogenetical and physiological investigations on these crops and for linseed breeding. Governmental sanction was received for the establishment of a Wing for Fundamental Plant Genetical Research and, of the four sections, two—namely, Cytology and Cytochemistry, and Genetics and Immunology, started functioning during the year. Work on the various schemes financed under the Second Five-Year Plan, as also by the Indian Council of Agricultural Research and the Commodity Committees, also progressed.

A large volume of advisory work and collaborative work, involving exchange of scientific information and seed material, was done as in previous years. The latter included the project, relating to the world genetic stocks of wheat and barley, being carried out in collaboration with the F. A.A. Considerable quantities of seed of improved varieties of crop plants were multiplied and distributed from Delhi and the substations.

The results obtained in the main lines of research in progress during 1957-58 are summarised below.

Plant Breeding and Genetics

1. *Improvement of Indian Wheats.*—As in previous years, the wheat work has been in progress at Delhi, Pusa, Indore, Simla, Bhowali and Wellington, with a view to evolving agronomically superior strains that are resistant to rust, smut and other diseases. The centres at Delhi and Pusa deal with breeding varieties suited to the plains of northern and eastern India, while the Indore centre mainly aims at evolving *durum* wheats for the wheat-growing tracts in central and Peninsular India. At the Simla and Bhowali substations, the work relates to the improvement of wheats in the northern hills, while the substation at Wellington concentrates on the improvement of *dicoccum* wheats commonly grown in the Nilgiris. Work has also been taken up on the assessment of the *chapati*-making qualities of Indian wheats. The genetical studies included more on the inheritance of rust and smut resistance and other characters.

(i) *Improvement of common bread wheats for the plains.*—A large number of selections made in progenies of crosses between Indian commercial bread wheats (*Triticum aestivum*) and rust resistant parents were found to be highly resistant to one, two or all the three rusts under artificial conditions of infection, and also to possess good grain quality and other desirable agronomic characters. Particularly promising performance was given by selections obtained from crosses involving Rionegro, Frontiera, Cometa Klein, N. P. 790 and Kenya 184 P. 2. A. I. F. on the one hand and N. P. 710, N. P. 718, C. 281, C. 591, C. 518 and N.P. 781 on the other. In progeny-row trials conducted with 684 selections under irrigated conditions and with 738 under rainfed conditions, several selections were found to be superior in yield to the controls C. 281, N. P. 718, N. P. 797 and N. P. 720. Some of these selections gave encouraging results at many other places, such as Simla and Bhowali (northern hills), Malda and Berhampore (West Bengal), Pusa (Bihar), Indore (Madhya Pradesh) and Wellington (Nilgiris—South India).

Considerable progress has been made in the project for incorporating resistance to loose smut disease in the variety N. P. 775, and in the one pertaining to the introduction of awns in the awnless rust resistant strains N. P. 797, N. P. 798 and N. P. 799; a number of promising selections have been obtained.

Some foreign *durums*, such as, Gaza (E. 931), Arabian *durum* (E. 2025), Egyptian *durum* (E. 2158), and an indigenous *dicoccum* wheat (I. C. 1057), are being used extensively as source of rust resistance in interspecific crosses with the common bread wheats (*T. aestivum*), *e.g.* Pb. C. 281, Pb. C. 591, N. P. 710 and N. P. 718. In F_4 and F_5 generations of these crosses, as also in some backcross progenies, a number of selections were obtained which combine in them a high degree of rust resistance and good grain quality.

In seedling resistance tests, fixed strains, *e.g.*, HD (52) Nos. 1, 27, 35, 46, 58, 66, 67, 117, 134 and 146 showed resistance to 7 to 8 races out of the 14 Indian races of black rust. N. P. 114, N. P. 718, HD (52) Nos. 34, 60, 66 and 77, HD (53) Nos. 87, 10, 106, 110, 121 and 134 were found to be highly resistant to loose smut.

At Pusa (Bihar), progeny-row trials were conducted with 445 rust resistant hybrid derivatives, many of which gave promising performance. In seedling resistance tests conducted with six hybrid strains, HP (55)-11, HP (55)-13 and HD (55)-35 were found to be resistant to 12 to 13 races out of the 14 races of black rust used in the tests.

(ii) *Improvement of common bread wheats for the hills.*—At Simla, about 1400 progenies derived from 194 crosses in F_1 to F_{10} generations were studied. About 18,000 single plant selections were made in the field on the basis of reaction to diseases and other agronomic characters. In progeny row trials conduced with 345 promising selections, a number of the selections outyielded the control, besides possessing better grain quality and disease resistance.

At the Bhowali Centre, 44 crosses comprising 288 families were studied for making suitable selections.

(iii) *Improvement of durum wheats.*—Three *durum* strains, namely, H. I. 9/51-20-1|1, A.M. 24 and B.R. 4 have consistently outyielded the local wheats at several stations in Madhya Pradesh. A number of other selections in advanced generations have given indications of high promise in the preliminary yield trials conducted at Indore and at several outstations.

Out of the 500 varieties under study, 31 were found in field resistance tests, to be completely free from black rust. In segregating populations of 111 *durum* crosses, 660 selections were made.

(iv) *Improvement of dicoccum wheats.*—The promising *dicoccum* selection P. D. 13 (now designated as N. P. 200), which is high yielding and resistant to brown rust under field conditions, was released to farmers in the Nilgiri and Palni hills of Madras State. Promising selections of the *dicoccum* cross (I.C. 1131 x Local) F_5, which are completely resistant to brown rust, were put in small scale trials. Some of these cultures were also found to possess the semi-free threshing character.

(v) *Improvement of the chapati-making qualities of Indian wheats.*—Studies on the mixability of wheat flour with flours of other cereals have revealed that wheat flour can be mixed with 15 to 20 per cent tapioca, *jowar, bajra,* barley or gram flours without adversely affecting its sweetness, palatability and chapati-making qualities. Tests on the chapati-making qualities of hill wheats have shown that N. P. 792 and N. P. 770 are very good for this purpose as compared to N. P. 813, Ridley, N. P. 809 and Simla local.

(vi) *Assessment of foreign wheat varieties.*—A collection of 1495 foreign wheat varieties was grown for maintenance and study; these included 117 items received this year through the F.A.O. and other foreign agencies. Of these 117 exotics, 29 were completely free from yellow rust, 8 from brown rust and 15 from black rust. The variety, Yuma x 57818, was free from both black and yellow rusts. E. 4263 and E. 4265 from brown and yellow rusts and E. 4253 from black and brown rusts

In seedling resistance tests, out of the fourteen varieties tested against all the individual races of black rust, E. 1844, E. 2842, E. 2845, E. 3072, E. 3123 and E. 3133 showed resistance or semi-resistance to all the 14 races of black rust. E. 2842 and E. 3133, which were highly resistant to all the races of black rust, including the most virulent races 122 and 15 C, appear to be particularly promising for breeding work. E. 930 was also found to be resistant to race 122. Eleven, out of the 26 *Agropyron* species tested, showed resistance to race 15C and 7 species to race 122.

In the loose smut resistance tests, out of the thirteen varieties tasted, E. 581, E. 997, E. 2025, E. 2140, E. 2623, E. 3117, E. 3319 and E. 3320 showed complete freedom from this disease.

(vii) *Yield trials of promising varieties and strains.*—The results of the regional wheat trials with N. P. varieties of the N. P. 700—series, have indicated the superiority of several N. P. varieties over the local strains in most places. Thus, N. P. 799 and N. P. 792 outyielded the local varieties at Madanapalle (Andhra Pradesh), N. P. 710 and N. P. 792 at Dharwar (Mysore State), N. P. 718 at Dabhoi (Bombay State), N.P. 710 at Bagwai (Madhya Pradesh), N. P. 797 and N. P. 799 at Cuttack (Orissa), N. P. 720 and N. P. 710 at Jeypore (Orissa), N. P. 718 at Shri Ganganagar

(Rajasthan), N. P. 758 and N. P. 718 at Umrala (Saurashtra—Bombay State), N. P. 758, N. P. 799 and N. P. 720 at Etawah (Uttar Pradesh) and N. P. 710 at Berhampore (West Bengal).

Among the newly evolved N. P. varieties of the N. P. 800—series, such as, N. P. 822, N. P. 823, N. P. 824, N. P. 825 and N. P. 826, the variety N. P. 824 appears to be very promising in the regional trials. At Panchi Gujran (East Punjab) it gave the highest yield of 3292 lbs. per acre as compared to the standard variety, N. P. 718, which yielded only 2058 lbs. per acre. At Vijapur in Bombay State, N. P. 824 stood second, yielding 1153 lbs. per acre, while N. P. 826 stood first (1188 lbs. per acre); K. C. N. 179, recently evolved by the Bombay Department of Agriculture yielded 821 lbs. per acre. At Delhi, N. P. 824 topped in yield (2836 lbs. per acre) under irrigated conditions and stood second (1627 lbs. per acre) in un-irrigated trials. At Indore again N. P. 824 occupied the second rank (820 lbs. per acre).

(viii) *Genetics of rust resistance and other characters.*—In the study of genetics of rust resistance, progenies of 32 crosses were tested in the seedling stage against races—15, 15C, 15C (colour mutant), 21, 42-B and 75 of black rust. For race 15, resistance appeared to be controlled mostly by a single dominant factor, except in the cross, N. P. 718 x N. P. 790, where two duplicate genes seemed to operate. In one cross, an inhibitory gene was involved in the manifestation of susceptibility. In the case of race 15C, susceptibility was found to be dominant and controlled by one or two genes. Reaction to race 75 was observed to be controlled by duplicate genes in some crosses, while a monofactorial difference was observed in certain other crosses. Reaction to race 42-B was simply inherited, with dominance of resistance, while resistance to race 21 was controlled by one or two duplicate factors. It appeared that the colour mutant of race 15C is genetically different from the parent race, 15C.

Reaction to black rust in the field was observed to be controlled by duplicate genes in crosses of Kenya 184 P_2 A.I.F. Three factors appeared to control the field resistance of Frontiera and La Prevision to brown rust. Crosses involving N. P. 785 and La Prevision indicated a similar situation in respect of field resistance to yellow rust.

Characters like shattering of the grain, glume colour, glume hairiness etc. were each found to be controlled by a single gene. Grain colour in La Prevision seemed to be governed by duplicate genes, while that in N. P. 785 by one gene.

(ix) *Breeding varieties suited to different levels of fertility.*—Trials were laid out at Delhi, Pusa and Karnal with a number of recently-evolved N. P. wheat varieties and hybrid strains in advanced generations, with a view to finding out their response to different levels of fertility. At Delhi, N. P. 823, N. P. 824 and N. P. 798 performed well both under irrigated and unirrigated conditions and also under late as well as normal sowings. At Pusa, N. P. 826, HD (52)-70 and N. P. 797 gave the highest yields under unmanured conditions while under manured conditions HD-(53)-105, HD (52)-70 and N. P. 824 gave the best performance. At Karnal, N. P. 824, N. P. 828 and N. P. 826 were the top yielders under unmanured conditions while under manured conditions, N. P. 824, HD(52)-27 and N. P. 826 were the best-yielding strains. N. P. 824 was observed to be consistently high yielding at all the places under all conditions and this is in conformity with the results obtained in the regional N. P. wheat trials also.

2. *Breeding rust and smut resistant barleys* :

The work on the improvement of barley was in progress at Delhi and at the Wheat Breeding Substations at Simla, Pusa, Wellington, and Bhowali A set of 147 exotic varieties, some of which were received through the F.A.O., was tested against rusts under artificial conditions of infection in the field. Among these, 46 were found to be free from yellow rust, while 13 were free from black rust. Sven varieties, namely, E.B. 225 (variety C.I. 7324), E.B. 231 (Balder), E.B. 243 (Hordeum "Yener"), E.B. 274 (Pallidum—...K—11856), E.B. 281 (Krughik 21—K—13031), E.B. 293 (Jrigai—K—16928), and E.B. 294 (Ahlteshi—K—17828) exhibited combined resistance to both black and yellow rusts.

At Wellington, crosses attempted between the local and B. 122 and B. 150 have resulted in the production of lines possessing combined resistance to yellow rust, loose smut and covered smut, coupled with all the desirable characters of the local variety.

3. *Hybrid Maize*:

During the year, 1650 inbred lines were sown for multiplication, selection and further inbreeding. About 342 inbred lines were selected on the basis of plant, ear and agronomic characters and further inbreeding was carried out in them. One hundred and nine top crosses, 99 single crosses, 89 locally-produced double crosses, 130 exotic varieties and 19 varietal crosses were studied in 10 different replicated trials. The locally-produced double cross, (T. 61 x Hy) x [My B-I x P4 A...y)-13y], gave the best result; it yielded 3775 lbs. per acre, which was 120 per cent. more than the check, K.T. 41, a top-performing local open pollinated variety. Among the exotic hybrids, the following appeared promising: Oh 7 x C.I. 21 E, Texas 32, Funks 54188 and Texas 26. These hybrids gave respectively 110 per cent., 71 per cent., 116 per cent. and 92 per cent. more yields than the check, K.T. 41. Two top crosses, namely, B 5-6 x K.T. 41 and P5-1-2 x Amarillo de Cuba, also gave high yields; the former yielded 87 per cent. and the latter 100 per cent. more than K.T. 41.

4. *Improvement of millets* :

(i) *Jowar.*—Among the fertile F_1 hybrids of the male-sterile Texas Blackhull Kafir with indigenous strains, the hybrid with I.C. 3437 was the best in regard to hybrid vigour and it gave an increase of 89·82 per cent. in per plant grain yield over the mean of the two parents and 36·94 per cent. over I.C. 3437, the higher yielding parent. The male-sterility observed in the indigenous strain I.C. 2360 in the year 1955 was found to be of a cytoplasmic type, there being an indication of an interaction between cytoplasm and nuclear factors. This indigenous male-sterile line, which possesses almost all the desired features of a grain type, holds much promise in the production of hybrid *jowar* seeds as it can be utilised directly for this purpose.

Twenty-two promising selections for fodder purposes have been made in the progenies of the backcross, (T. 263 x Sweet Sudan grass) F_1 x T. 263, and in F_2 of the cross, T.263 x Sweet Sudan grass. A few early-maturing and white-chalky-seeded dual-purpose types have also been selected in F_3 of the cross, E.C. 4315 x Early Prodigy. These selections will be tested further in a progeny-row trial.

In a preliminary replicated-row test conducted with 76 early and medium-maturing strains, none gave statistically superior grain yield than the control—Early prodigy (682 lbs. per acre); the best among the strains, I.C. 3565 gave a calculated yield of 792 lbs. per acre.

(ii) *Bajra.*—About 607 cultures, including selfed and sibbed progenies, were studied for their various plant characters. Two recently-introduced exotic varieties, E.C. 11793 and E.C. 11794, from Ghana appeared to be promising; they were as early flowering (50-55 days) as the local standard, T55, and possessed very bold, attractive grains (500-grain weight: 6·5 and 7·5 gms., respectively), as compared to 3·5 gms. in T55 and 4:5 gms. in the boldest indigenous variety, I.C. 1722 in the collection.

In a trial of 80 (S_2) top crosses, two top crosses, namely, I.C. 1724/2-1 x T55 and I.C. 1724/1-3 x T55, gave significantly superior grain yields (1081 lbs. and 1068 lbs. per acre respecticvely) as compared to 793 lbs. per acre given by the control, T55.

Genetical studies on the pistil-less variant indicated that the variant phenotype was a triple recessive; these observations will be confirmed by further studies.

5. *Cotton*:

Forty four selections made in *Gossypium hirsutum* were tested for performance in a replicated progeny-row test. Some of these, such as, S.41, S.30, S.35, S.27, S.19 and S.20 have given encouraging results. Their average yield of *kapas* per plant varied from 46·9 to 66·4 gms., mean halo length ranged between 26·8 to 33·2 mm. and ginning percentage varied from 29·0 to 36·9; the corresponding values for the standard variety, H.14 were *kapas* yield—40:9 gms. per plant, mean halo length—24:9 mm., and ginning out-turn 34·0 per cent. The selections will be further tested next year.

In *G. hirsutum*, 129 exotic cultures were added to the collection; many of them were received through the courtesy of Prof. David Ter-avenasyan of the U.S.S.R. Embassy in New Delhi and several others were received under the Indian Central Cotton Committee's project for the establishment of a germplasm bank. Although a majority of these introductions were susceptible to jassid attack, several among them appear useful as breeding stocks; the staple length in them ranged between 27·9 and 34·6 mm. and ginning out-turn between 35·5 and 42·1 per cent. The American introduction, S.A. 594, possessed a remarkably large boll number per plant, although boll size in it was rather very low; however, this type may be useful as a source of high boll-bearing capacity.

6. *Linseed*:

In a replicated yield test conducted with 14 promising rust resistant selections, five, namely, S.208, S.273, S.218, S.214 and S.209 gave good performance as compared to the controls which included the rust resistant strain, N.P. (R.R.) 9, and H. 614-1, a high yielding strain recently evolved by the U.P. Department of Agriculture; the latter strain, however, is susceptible to rust. The performance of the new rust resistant selections will be tested on a larger scale next year.

A number of crosses and backcrosses have been made to study the inheritance of quantitative character in linseed, *e.g.*, earliness, seed size, and seed number per capsule, etc.

7. *Pigeon pea*:

As a result of a replicated progeny-row test carried out during the year under report, a number of high yielding, wilt resistant strains have been isolated. Some of these promising selections, such as S.68, S.86, S.76 and S.37 are bold seeded. Their yields were significantly superior to the wilt-resistant strain N.P. (W.R.) 15, evolved earlier in this Division, but statistically at par with the high-yielding variety, T.105, from Uttar Pradesh. However, mortality due to wilt ranged from 0·0 to 6·6 per cent. in these selections, as well as in N.P. (W.R.) 15, whereas the U.P. Type 105 showed 76·6 per cent. wilt mortality.

Two exotic strains—Saragateado and Florido, introduced from Puerto Rico, are being utilised in the breeding programme; the former possesses very bold seeds (100-seed weight 20·5 gms.) and the latter has about 7-8 seeds per plant.

8. *Spices and condiments*:

(i) *Improvement of essential-oil-bearing plants.*—Work on the improvement of some essential-oil-yielding species, like *ajwain* (*Carum copticum*), *dhania* (*Coriandrum sativum*), *jeera* (*Cuminum cyminum*) *Saunf* (*Foeniculum vulgare*) and *sua* (*Anethum graveolus* and *A. sowa*) was continued at Delhi and at sub-stations at Jamnagar, Pusa and Katrain. In small-scale yield tests, several selections, such as, Nos. 95, 96, 82, 5, 12, 66 and 147 of *ajwain*, Nos. 213, 212, 207, 192, 129, 239, 21 and 229 of coriander, Nos. 195, 197, 269, 237 and 228 of *saunf* Nos. 115, 119, 297 and 346 of *sua*, and Nos. 109, 205 and 118 of *jeera*, made in the indigenous material at the various centres, were observed to give 2 to 4 times more yield than the local. In many selections, the essential-oil content was found to be promising. Some of the material introduced from abroad has shown high oil content, although these exotics are in general late-maturing and poor in yield. These results are being confirmed and further selection work is under way to isolate lines combining high yield with high oil-content.

(ii) *Chilli.*—The high resistance of "Puri Red" to the chilli posaic virus was further established under controlled conditions. The F_1 hybrid N.P. 46 A x Puri Red appeared in preliminary tests to be resistant, indicating the dominance of resistance. These results will be confirmed by further study.

Forty-two different types of chilli were grown in a replicated trial for a study of quantitative characters contributing to yield and of the inter-relationships between these characters.

9. *Vegetables*:

(i) *Tomato.*—Two intervarietal F1 hybrid combinations—(Sioux x Prosperity and Pusa Ruby x Prosperity) gave in an yield test remarkably high yields (calculated acre yields: 738·6 and 586·5 mds.); the corresponding values for the check varieties—Prosperity, Pusa Ruby, Sioux and Improved Meeruti, were 545·7, 734·3, 419·9 and 458·6 mds. per acre respectively. Male sterility is being introduced into the best-combining

varieties for facility in the commercial production of hybrid seed. Of the three male-sterile conditions, namely, "pollen sterile", "stamenless", and "closed-anther", the closed-anther character is more desirable. The closed-anther type of male-sterility was observed in the indigenous variety, Improved Meeruti.

(ii) *Onion.*—The male-sterile lines received so far from the U.S.A. for hybrid seed production have either white or yellow bulbs. Two sets of male-sterile lines, namely, A, B and C lines, received earlier were found to be comparatively lower yielding than the standard yellow variety, Early Grano. Five more sets of male-sterile lines were obtained last year and their bulbs have been harvested this year for seed production next season.

(iii) *Brinjal.*—With the availability of a "closed-anther" mutant from Canada, investigations on hybrid vigour in brinjal were restarted. It may be mentioned that, some years ago, the hybrid (Muktakeshi x Clustered White) designated as "Pusa Purple", had given excellent performance. Crosses have been effected with a view to transferring the "closed-anther" character into a number of desirable brinjal types.

(iv) *Bhindi.*—F_4 progeny was raised from the 14 selections made last year in the F3 of intervarietal crosses. These selections remained completely free from symptoms of the yellow-vein mosaic virus disease, which is very prevalent in cultivated *bhindi*. One of these selections gave nearly twice as much yield as the standard variety, "Pusa Makhmali". All the selections were 2 to 13 days earlier than "Pusa Makhmali".

(v) *Peas.*—F_2, F_3 and F_4 progenies of the crosses involving Early Badger, Bonneville, Green feast and Asauji were studied for making promising selections. Some of the selections showed marked improvement over the standard variety, Early Badger, in pod-length, pod-colour and number of pods per plant. Cultures resembling Greenfeast, but early in fruiting, have also been selected.

(vi) *Carrots and turnips.*—In the F_2 and first back-cross progenies of the crosses between temperate and Asiatic (local) varieties of carrots and turnips, several good roots superior to the local varieties were selected for the study of seed production in the plains. Over 90 per cent. of the selected plants flowered and set good seeds at Delhi. In India, the good quality, "temperate" varieties of carrot and turnip are unable to produce a good crop of seed in the plains and the object of this work is to evolve superior varieties which would be able to do so.

(vii) *Watermelon and muskmelon.*—Some of the Japanese varieties of watermelon again showed higher sugar content than the indigenous material. The varieties, Giant Shin Yamato and Nagaoka Fukin, which showed 12 per cent. total sugar and good bearing, require special mention. In the case of muskmelon, the Lucknow types, which were selected previously for high sugar content and good bearing, were observed to be pure for fruit characters and high sugar content. It is now proposed to multiply their seed for further trial. A Russian variety, Arbaceshak-219, has appeared to be promising as regards fruit size, yield and sugar content.

10. *Pasture grasses and legumes:*

70 new accessions of grasses and 17 of legumes were made during the year. In a replicated yield trial conducted with 28 strains of grasses, *Brachiaria mutica* (E.C. 9715—Australia), and *Setaria sphacelata* (E.C. 7430—Australia) gave the highest acre-yields (calculated) of green fodder in four cuttings—798·8 and 675·4 mds. respectively. In another replicated yield trial conducted under entirely rain-fed conditions at Todapur farm with 9 strains of grasses, *Cenchrus setigerus* (Ajmer) and *Pennisetum ciliare* (E.C. 5600-U.S.A.) gave the highest acre-yields (calculated) of green fodder in three cuttings—360·0 and 218·0 mds. respectively. No adverse effect of inbreeding for 3-4 generations on vegetative vigour and seed setting was observed in the 16 strains of *Cenchrus, Pennisetum* and *Dichanthium* under study.

11. *Vegetable Seed Testing :*

Five hundred and fifty-six seed samples of vegetable and field crops were registered and tested for purity, germination and moisture content. The data obtained are being summarised with a view to fixing standards suited to Indian conditions.

Rapid tests for germination were carried out with a number of chemicals and dyes which give a differentiated colour reaction with live and dead seeds. Sodium biselenite and tetrazolium bromide, in concentrations of 1 to 0·5 per cent. and durations of 4 to 35 hours, were found suitable for this purpose. Fast green, which was used for this purpose for the first time, was also found to be suitable in concentrations of 0·01 to 0·05 per cent. and durations of 24 to 48 hours.

12. *Genetic variability in algae:*

Studies on algae were taken up with regard to general morphology, nitrogen fixation, physiology and general metabolism and translocation. The rare and little known alga, *Botrydium divisum*, was collected and studied *in vivo* and *in vitro*. A new terrestrial species of *Oedogonium* (*Oe. randhawae* sp. nov.) was described in detail. Twenty-eight forms of diatom, representing twelve genera, were reported. A *Nostoc* strain isolated from the root nodules of Egyptian clover has been found to fix elementary nitrogen. Of the total nitrogen fixed, about 80 per cent. is liberated into the medium in the form of extracellular nitrogen. It is found that by increasing the concentration of molybdenum, not only can the nitrogen fixation be enhanced, but the period during which extracellular nitrogen is liberated can also be considerably prolonged. The diatom, *Nitzschia palea*, was found to have a higher level of tolerance to nitrogen and phosphorus and as such an inhibitory effect on this alga due to a nitrogen excess is improbable in natural waters. Colchicine, at a concentration of 0·01 per cent., was found to stimulate growth in *Selenastrum westii*. At higher concentrations, the cells increase in size and become rounded, but on subsequent subculturing on colchicine-free medium, such enlarged cells revert to the normal narrow, lunar-shaped cells as in the control.

Cytology and Cytogenetics

13. *Induced polyloidy as a means of crop improvement*:

(a) *Toria.*—Induced autotetraploids of *toria* (*Brassica campestris* **var.** *toria*) continued to do well. Yield trials were conducted in Delhi as well as in the States of Punjab, Himachal Pradesh and Bihar. Both at Delhi and at Bihar, the tetraploid elite stocks out-yielded the diploid control by a margin of 16 to 17 per cent. The yield recorded at Delhi was 10 mds. per acre. In the trial conducted in Himachal Pradesh, the tetraploid yielded less (not significantly) than the diploid local under unirrigated conditions, while under irrigated conditions it yielded more (4·5 mds. per acre). Results of the trial in Punjab are awaited. While the suitability of tetraploid *toria* for the sub-montane tract is still to be established, the tetraploid is very well suited for cultivation in the Bihar State where, it appears, it can profitably displace yellow *Sarson*, which is less hardy. During the year, experiments were started to build up selection indices in tetraploid *toria* in order to enhance the efficiency of selection. The genetic correlation between yield components and their heritability is being estimated.

(b) *Linseed.*—Further progress was made in the selection for high seed fertility among autotetraploids of linseed. N.P. (R.R.) 63 has given particularly promising results, as can be seen from the fertility status observed during the past and present years.

Year	Fertility Classes (No. of seeds per boll)									
	0·1 to 1·0	1·1 to 2·0	2·1 to 3·0	3·1 to 4·0	4·1 to 5·0	5·1 to 6·0	6·1 to 7·0	7·1 to 8·0	8·1 to 9·0	9·0 to 10·1
1956-57	0	0·5	6·7	37·3	41·5	12·7	1·2	0	0	0
1957-58	0	0	0·4	1·7	13·1	58·9	21·0	4·3	0·1	0

(c) *Berseem and Senji.*—The promising tetraploid berseem cultures isolated during last year were grown. They maintained their superiority in growth and further selections were made, based on forage yield, dry matter content and seed fertility. Though the dry matter content was in general lower in the tetraploid in comparison with the diploid, there were several tetraploid cultures which had a dry matter content equal to or more than the corresponding diploids. The dry matter content was negatively correlated with the yield of green fodder and it was also found to increase after the second cut in both diploid and tetraploid cultures. The capacity to regenerate after a cutting was similar in diploids and tetraploids.

A progeny row trial of some C2 and C3 cultures of tetraploid berseem with their diploid parents was conducted. The results showed that the tetraploids gave a significantly higher yield than the diploids. In order to bring about a thorough recombination of the desirable genotypes, a polycross nursery was raised. Each selection was replicated thrice and each small plot was covered with a cage. A beehive was kept inside each

cage at the time of flowering. Cytological studies showed that there were on an average 2 to 3 quadrivalents in the tetraploid cultures. Seed fertility showed a further rise in the tetraploids. During the year, six new strains were treated with colchicine to produce additional tetraploid types. Three diploid strains were also first irradiated with 7200 and 11000 r of X-rays and later treated with colchicine. The objective of this experiment was to induce some segmental interchanges so that the auto-tetraploid produced behaves more as a segmental allotetraploid. The performance of tetraploids of *Senji* was poor this year also and it appears that the chances for improving the yield of this crop by polyploidy breeding are slender.

(d) *Ornamental plants.*—Tetraploid plants which produce bigger and more showy flowers than the corresponding diploids, were experimentally produced in several ornamental plants including Antirrhinum, Calendula, Phlox, Acroclinum, Larkspur and Asters. The cytological and breeding behaviour of the induced tetraploids is being studied with a view to evolving highly fertile and relatively stable tetraploid forms.

14. *Induction of mutations in crop plants*:

(a) *Wheat.*—Several mutations were found in the X_2 and X_3 progenies of the varieties, N.P. 797, 798, 799, 809 and C-591. They related to the following characters: chlorophyll development, grass clump nature, early or late maturity, stiff and short straw, fine and long straw, lax or dense ear, speltoidy, compactoidy, square-headedness, awning, black awn colour, glabrous glumes, coloured glumes, grain colour and rust resistance. Among these, the early, stiff-straw, and fully-bearded mutants of the varieties, N.P. 797, 798, 799 and 809, and the stiff-strawed and rust-resistant mutations of C-591 are of economic interest. In an yield trial (compact family block design with 5 replications), the bearded N.P. 809 mutant gave a significantly higher yield than the parent strain. Among the bearded N.P. 809 mutants, one type had in addition a shorter straw and compressed earheads. The stiff-straw mutants were of various types differing in height, ear density and thickness of straw. All of them, however, had a reduced number of internodes, a shorter basal internode and a larger cross-section area particularly in the middle internodes in comparison with the parent strains. Several mutants resistant to races 15, 15C and 21 of black rust were found when the X progenies of fast-neutron-irradiated C-591 were tested by artificial inoculation of young seedlings with each of these races individually. The breeding behaviour of these plants is being studied.

In view of the economic interest of the awn mutations, the mode of their inheritance in crosses with the control plants of the parent strain was studied. The variety N.P. 809 belongs to the 'tipped-1' class (awns 1 to 2 cms. in length) and has the genotype B_1 B_1 b_2 b_2 hd hd. F_1 plants from the cross, fully bearded mutant x control, were tipped. Tipped and fully bearded plants occurred in the generation in the ratio of 3:1 (observed 33 tipped and 14 fully bearded). No differences could be detected in the karyotypes of the control and fully bearded N.P. 809. The bearded mutation could thus have been caused by a cryptic deletion or intragenic changes at the B_1 locus.

(b) *Linseed.*—Irradiation of tetraploid and diploid N.P. (R.R.) 10 and N. P. (R. R.) 63 with different doses of X-rays, ranging upto 100,000 r units, was done. The X_1 plants were studied cytologically.

(c) *Tomato.*—An interesting mutation obtained in the variety Meeruti, is a plant with completely red skin colour in the fruits. The green colour in the stem-end side of fruits, which persists even on maturity, is an undesirable character in this otherwise-popular variety.

(d) *Ornamental plants.*—A number of phenotypic changes pertaining to flower colour, form and size have been induced in several winter annuals, including annual Chrysanthemum, Cosmos, Pansy and Cynoglossum. Particularly interesting results have been obtained with annual Chrysanthemum, in which changes in flower from single to double of various types and from non-tubular to tubular corolla have been produced.

15. *Culture of excised plant embryos*:

Embryos were found to abort at the 4-to 8-celled stage in the cross *Corchorus olitorius* x *C. capsullaris*. Suitable media were standarised to culture ovules and young embryos of *C. olitorius*. The addition of gibberellic acid (I ppm) was found to induce a marked stimulation in the growth of young embryos. The culture of young embryos in the cross *Hibiscus cannabinus* x *H. sabdariffa* and *Lycopersicon esculentum* x *L. peruvianum* was also taken up.

16. *Monosomic analysis in wheat*:

F_2 populations from the cross, Chinese Spring monosomes X Cometa Klein, were tested for resistance to races 13 and H of yellow rust at the seedling stage. A monohybrid segregation was observed in the case of race 13 and a dihybrid ratio was obtained for race H. From the skewed segregations observed, it was concluded that chromosome IX of Cometa Klein carries the gene for resistance to race 13 and chromosomes IV and VI the genes for resistance to race H.

17. *Cytological Techniques*:

The propiono-carmine schedule described in an earlier report was found to give a bright staining of the chromosomes in some algae. The following technique was standardised for staining the nucleus of yeasts. Yeast cells, kept young by repeated sub-culturing, are centrifuged, washed twice in distilled water and smeared on slides coated with a little egg-albumen. The cells are treated with 0.002 M 8-hydroxyquinoline for 1 hour and are then fixed first in osmic acid vapour for 30 seconds and then in chloroform for 30 seconds. The slides are passed through grades of alcohol and washed with distilled water. They are then immersed in 0·7 M NaCl solution for 2 hours at 51-C. They are again washed in distilled water and later hydrolysed in HCl at 60·C for 5 to 7 minutes. This is followed by washing in distilled water and buffer. The slides are then kept for 3 hours in Giemsa stain comprising 96 cc. of phosphate buffer of pH 7·0 and 4cc. of the stain. After dehydration, mounting is done in balsam. In preparations made in this way, the nuclei are brightly stained and well-differentiated, the centrosomes are clear and the process of nuclear division and movement to daughter cells could be studied.

18. *Polyploidy and the genesis of the leguminous nodule*:

Cytophotometric measurements of DNA content were made in the nuclei of root tips, differentiated root tissue and nodules of diploids and colchicine-induced tetraploids of berseem (*Trifolium alexandrinum* L) and *Senji* (*Melilotus indica* All.) The measurements showed that cells from the meristematic and differentiated regions of roots had $2n$ DNA value while most of the cells in the nodule in the diploid and tetraploids had $4x$ and $8x$ DNA content respectively. Cytological studies were also made and from the data it appears that while disomatic cells, when present, may get preferentially infected, normal diploid cells may also get infected and become polyploid subsequently.

Crop Physiology

19. *Study of drought resistance in wheat* :

The study of the rate of development of grain and of yellowing of leaves, stem and ear in the varieties Pb C 281 and N.P. 720, grown in pot-culture, under normal water supply (W) and intermittent drought during the post-ear emergence period (D), was repeated. Late sowing (December 15 as against November 15) was also included as another variate in order to see the effect of atmospheric drought during the grain filling period. It was found that in spite of quicker yellowing of leaves and stem under D, under the first 4 weeks or so after dehiscence, grain development was little affected as long as the ear remained green and it declined later when the ear yellowed more rapidly under D. Thus the reduction in 1000-grain weight under D could be clearly accounted for. The grain number per ear was reduced under drought. It was observed last year that although the water content of the ear was not affected by D, grain number was reduced and it was suggested that reduction in the water content of the flowers, which constitutes a very small proportion of the total weight of the ear, may not be detected when the overall water content of the ear was determined. This explanation was borne out this year when the water content of a few central spikelets (without awns and rachii) was compared; their water content was reduced under D, whereas that of the ear was unaffected.

The two varieties had equal grain number per ear; Pb C 281 had a much higher 1000-grain weight, whereas N.P. 720 had a larger ear number. The former variety dehisced earlier by about 4 days. The ear of N.P. 720 yellowed more quickly, under W and D, than that of Pb.C. 281 and thus its smaller 1000-grain weight could be explained. It is interesting to note in this connection that the chlorophyll (a and b) content of the ear of N.P. 720 was consistently lower than that of Pb.C. 281 during the period the ear was completely green. This handicap in N.P. 720 was, however, more than adequately counter-balanced by its higher earing capacity with the result that in the first sowing N.P. 720 outyielded Pb.C. 281, under both W and D, by about 5 per cent. Under late sowing, however, Pb.C. 281 outyielded N.P. 720 under D in spite of its lower ear number, the reverse being the case under W; Pb. C. 281 may be regarded as being more resistant to soil and atmospheric drought than N.P. 720 and this resistance may be attributed to slower yellowing of the ear.

In order to see that the ear did contribute to grain-filling, it was shaded on alternate days during a period of a week or so on several occasions and it was found that the increase in grain weight diminished due to shading.

20. *Plant Hormones*:

In a field trial with the wheat variety, N.P. 710, spraying with alpha-naphthyl-acetic acid (40 p.p.m. with wetting agent) about 4 weeks after sowing, increased the yield, though not significantly, by about 200 lb. per acre (unsprayed control, 2000 lb/acre). A similarly beneficial effect (though not significant) was observed last year. In a field experiment with the cotton variety, 216F, it was again confirmed that beta-naphthoxy acetic acid at 5 p.p.m. (with wetting agent) gave as much increase in yield of seed cotton as I.A.A. and N.A.A. at 40 p.p.m., when sprayed after the opening of the first flower; as the increase in yield was 370 lbs. over 1400 lbs. per acre of the unsprayed control, spraying with B.N.A. should prove very economical.

Control of *kans* (*Saccharum spontaneum*)—CMU-treated beds showed comparatively much sparse growth of *Kans* even after one year of its application; *lobia* (*Vigna sipensis*) did not, however, thrive as much as in control beds, thus indicating the persistence of CMU-toxicity in the soil.

21. *Plant Nutrition*:

In a field experiment with the wheat variety, N.P. 718, all the nine treatment combinations with boron (1·75, 3·5 and 7·0 lb/acre of boron application at showing and 45 and 80 days after sowing) significantly increased the grain yield to the some extent (control 3312 and boron, 3632 lb. per acre). In another experiment with the same variety of wheat, grain yield was increased to the same extent (control, 2680 and treatment, 2880 lb. per acre) by spraying 4 micronutrients (manganese, 246 and 492; zinc, 171 and 288; copper 127·5 and 191; molybdenum, 40 and 53 lb. either on the 50th or 95th day after sowing. A basal dose of 30 lb. N, 40 lb. P_2O_5 and 30 lb. K_2O per acre was applied in both these experiments. It may be noted that the unsprayed crop did not show any deficiency symptoms and as such this would appear to be a case of "hidden deficiency".

22. *Physiological investigations on autotetraploids of some oilseed crops (I.C.O.C. scheme)*

In a comparative study of the growth of *toria*, diploid T-22 and an autotetraploid elite A (*Brassica campestris* var. *toria*), under two spacings (2′ x 1′ and 1′ x 1′), two nitrogen levels (O and 20 lb. N/acre), and two sowing dates (31-8-1957 and 28-9-1957), it was found that the diploid under the 20 lb. N with wide spacing combination outyielded the auto-tetrapoid under all combinations of spacing and nitrogen, indicating thereby that the diploid responded better to more favourable conditions. This difference was largely due to more profuse branching of the diploid under wide spacing. The yield per acre was reduced under wide spacing due to lower number of plants and it was increased under late sowing.

Spraying with maleic hydrazide (500 p.p.m.) increased branching but affected fruit-setting adversely. Para-chlorophenoxy acetic acid had no favourable effect on yield, unlike in the 1955-56 season and in the 26-9-1957 sowing during the current season. As late sowing appears to be more favourable for growth, it is possible that the hormome spray did not act favourably because of early sowing.

23. *Co-ordinated scheme for investigations on citrus 'die-back' (I.C.A.R.)*:

Symptoms of potassium, calcium and phosphorus deficiencies were obtained in mandarin under water culture. In the early stages of potassium deficiency, there appeared in the leaf a continuous green area from the base of the midrib to the tip against background of yellow mesophyll interspersed with green veins and veinlets; later, pronounced curling, puckering and yellowing resulted. Under phosphorus deficiency, there developed in older leaves dull green patches which ultimately presented a burnt appearance. Under calcium deficiency, chlorosis started from the margins in younger leaves followed by drying of the affected portions. Seedlings of Rough Lemon, Sweet Lime, Sour Orange and Baduvapuli were also set up under water culture for studying the deficiency symptoms.

24. *Co-ordinated scheme on pre-soaking of seeds in nutrient salts (I.C.A.R.)*:

Reducing and non-reducing sugars were estimated in the water extract after soaking wheat grains in water (seed: water as 1:10 and time of soaking 6 and 24 hours). The quantity of reducing sugars in the extract increased with the length of the soaking period, whereas that of non-reducing sugars did not. On changing the water every six hours (in the 24-hours period), more of non-reducing sugars diffused out, whereas the quantity of reducing sugars was unaffected. On soaking grains of wheat and seeds of cotton in zinc sulphate solution (M/400) for 24 hours, it was noticed that the zinc content of the embryo and endosperm of wheat and of the embryo and testa of cotton increased over that of water-treated controls; zinc was estimated by polarograph.

Plant Introduction

(a) *New collection*:

During the year, 1293 items were introduced from abroad and 1441 seed samples, wild and cultivated, were collected from within the country. A survey of the saline regions of Rajasthan was undertaken with a view to collecting salinity-tolerant and drought-resistant plants. The grass species, *Elyonurus hirsutus*, was found to be very hardy and growing in low-rainfed areas, besides having salinity-tolerance. Wild-growing legumes, grasses and allied species of cultivated plants were collected from the hilly areas of Mysore and Orissa State; the collection of species of *Crotalaria, Desmodium, Atylosia, Solanum, Cucumis, Momordica*, and species of fruit trees, such as *Diospyros, Phyllanthus* and *Grewia*, may be mentioned specially. The Orissa hills appeared to abound in ornamental shrubs such as *Woodfordia floribunda. Jasminum pubescens, Indigofera pulchella, Erythrina indica*, etc. A short-stemmed, erect-growing variety of sweet potato was collected from Duduma (Orissa).

The interesting among the exotics including two varieties of *Pennisetum* received from Ghana, possessing markedly bold seeds and shor thick ears. A species of *Sorghum, S. propinquium,* belonging to *halepensia* group and reported to cross easily with the cultivated *Sorghum,* is considered useful for evolving a perennial sorghum. Seeds of *Bouea burmanica,* a plant producing mango-like fruits, were obtained from Burma. Seeds of *Stipa tenacissima* (*Esparto* grass), which is used for paper making and wax extraction, was obtained from Spain. Horticultural plants such as *Lilium, Gladioli,* varieties of grapes and berries were received from various sources.

(b) *Evaluation:*

Pulse Crops.—The newly-received soybean variety, Tamanishikki (E. C. 11740) from Japan, appeared to be a promising grain variety. A few other Japanese grain varieties *viz.,* Azeminori (E.C. 9310), Shakkinnashi (E.C. 9311), Yagi No. 1 (E.C. 9312), and Rikum No. 21 (E.C. 9316) are early and bold-seeded. A variety of vegetable cowpea, accessioned as E.C. 12275, was found to have attractive long pods, measuring 16-18 inches. Two pigeon-pea varieties, *viz.,* Saragateado (E.C. 9333) and Florido (E.C. 9334), both from Puerto Rico, appear to be useful as breeding stocks; the former has very bold seeds and the latter 7 to 8 seeds per pod. "Victoria" (E.C. 9908), A Russian variety of smooth pea was adjudged the best bold-seeded white smooth pea. Its seed was about 50 pod.

In oats, Boris Opus significantly outyielded, in an yield trial, the control, N.P. Hyb. 3; White Algerian closely followed Boris Opus. A French variety, Grignonnaise (E.C. 4711), remained green till the end of April. Unlike some other late types, this variety was free from the presence of sterile spikelets. Two Australian oats, *viz.,* Belar 2760 (E.C. 4447) and E.C. 4446, also appeared promising. A low-growing, broad-leaved legume, *Desmodium paleaceum* (E.C. 2973), from Nigeria, appeared to be tolerant to both heat and cold. It has been found to be rich in fat and mineral content.

Sweet-potato.—Two Chinese accessions, E.C. 12104 and E.C. 12106, having deep orange and yellow flesh respectively, gave good performance. The selection from the variety, Norin, producing attractive red-skinned and white-fleshed tubers, has done very well and is being multiplied for distribution.

Vegetables.—Of the newly-received varieties of tomato, a few dwarf types, *viz.,* Victor (E.C. 10310) from Japan, and accessions from Czechoslovakia (E.C. 11843, E.C. 11845 and E.C. 11847) appeared promising. Crack-proof (E.C. 4955) and Ace (E.C. 5628), both from the U.S.A., proved resistant to cracking.

In an yield trial with yellow and red varieties of onion, Early Grano (a yellow salad type) out-yielded all the other types, giving 42·4 lb. per plot as compared to 23·8-39·0 lb. given by the red types. The best among the latter was Delhi Red Selection, having medium-large bulbs, made from local stock.

Amongst the wrinkled seeded graden peas, the early variety, Laxton Progress No. 9 (E.C. 9092) from the U.S.A. and the midseason varieties, Climax (E.C. 8268) from Argentina, Morses No. 55 (E.C. 9089) from the U.S.A., and late types, *vis.*, Universal (E.C. 8921) and New Dwarf (E.C. 8916) from the U.K., Morses No. 66 (E.C. 9090) from the U.S.A. and Kelvedon Spitfire (E.C. 9344) from France appeared promising. The Argentinian variety, Climax, is being recommended for trial in Madhya Pradesh in comparison to the local variety 'Khaparkheda'. Ace (E.C. 8255) from U.S.A. may also be good for areas where winter is mild and of short duration.

In brinjal, a variety from Trinidad (E.C. 8973) appeared to be a prolific bearer. The fruits of this variety are long and purplish-black in colour. Some of the indigenous collections, *viz.*, Banaras Giant (I.C. 3500), Panipat Round (I.C. 2796), Black Beauty, Japanese Giant Long, Black Long Cluster, and a small-fruited variety (I.C. 4881) from Assam appeared to be resistant to *Phomopsis veseans* which causes the drying up of the affected parts and sometimes of the whole plants.

Two varieties of cabbage from Czechoslovakia, "Dobrovodski Pozdni" (E.C. 11839) and "Dittmarske rane" (E.C. 11841), formed cone-shaped solid heads and appeared to be good late varieties.

A variety of carrot from Greece, accessioned as E.C. 9981, appeared to be a good substitute for the early Asiatic carrots because of its earliness and unbranched root habit.

Medicinal plants.—Plantings of *Rauwolfia serpentina* and *Lophophora williamsii*, the latter a spineless cactus from the U.S.A. reported to be having hallucinating alkaloids, have been satisfactorily established.

Essential-oil yielding plants.—An interesting collection of wild and cultivated mints and of *Cymbopogon* species, yielding essential-oil, is being established. Two honey plants, *viz.*, *Pycnanthemum* sp. and *Lythrum salicaria*, have been observed to grow well.

Miscellaneous.—The tanin-yielding Canaigre (*Rumex hymenosepalus*) from the U.S.A. was observed to form root tubers in fair-sized bunches. A comprehensive collection of grain and pot-herb *Amaranthus* was built up during the year; an interesting range of variability has been found in them.

Herbarium.—A reclassification of the herbarium specimens was done with a view to setting up a separate section of economic plants and their varieties. The material has been classified into 25 different groups.

26. *Seed Production and Supply.*

(i) *Wheat.*—As in the previous years, this Division co-ordinated the supply of seeds of the New Pusa wheat varieties produced at the Botany and Agronomy Divisions at Delhi, A.R.S., Karnal, B.S.S., Pusa and the Wheat Breeding Sub-stations at Simla and Indore. Owing to the limited facilities available for multiplication of improved wheat varieties at the Institute, only 2420 mds. of seeds could be supplied as against the heavy demand of about 1143 mds.

(ii) *Other crops.*—The quantity of seed distributed is indicated below; this includes seed supplied from Delhi and from the Botanical Sub-station, Pusa (Bihar).

Crop	*Quantity*	
	Lbs. ozs.	
Paddy	7438 0	
Maize	3921 12	
Gram	1404 0	
Linseed	338 8	
Oats	803 8	
Barley	1352 5	
Arhar	3633 0	
Mung	710 0	
Urd	12 0	
Lentil	16 0	
Sesamum	156 0	
Safflower	52 0	
Brassica	9 8	
Bajra	16 0	
Jowar	3 0	
Tobacco	0 12	
Vegetables	2413 0	(In addition 1439 packets of vegetables were also supplied.)
TOTAL	22279 9	

27. *Vegetable Breeding Substation, Katrain.*

Due to continuous rains during the spring, summer and rainy season of 1957, summer crops received a great setback and autumn sowings and transplantings were very much delayed. Consequently, a proper evaluation of the experimental material was not possible, especially in the case of summer vegetables. Favourable weather during the spring and summer of 1958, however, enabled timely sowing and transplanting of summer vegetables and proper handling of the selfing and crossing programme in cruciferous vegetables.

In the assessment of varietal collections, some promising varieties were found in cabbage, knol khol, carrot, turnips and radish and in summer vegetables such as cucumber. The Japanese cabbage, "Nozak Chusei", was the best early drumhead type. A knol khol variety from Switzerland (E.C. 11447) is ideal in that the 'bulbs' are very shapely and the leaves are characteristically short. It was however observed to be poor in seed production. The earliest carrot was a variety from Greece (E.C. 9981). For growing during spring-summer in the hills, two Japanese, white, winter radishes were excellent; these did not bolt till late in the season. The cucumber variety, E.C. 5082, from Japan was again observed to be the earliest and longest-fruited variety.

Testing of inbred lines for the isolation of self-incompatible, but cross-compatible lines, having good combining ability was further continued. In the turnips variety, Snowball, one combination 9L x 3C gave an 80·6 per cent increase in the yield of roots over the crop raised from the nucleus seed. In the variety, Golden Ball, the cross 5I x 4F gave a 54·1 per cent increase. Four combinations in the cabbage, 'Golden Acre', were remarkable for their percentage of head formation and size of heads. Increases were also observed in knol khol. Differentiation of groups on the basis of alleles of the self-incompatibility gene was also further continued in cabbage, turnip knol khol and radish.

From the crosses made between Asiatic and temperate varieties of carrot, turnip and radish, selected F_2 plants were grown for seed production at Delhi and at Katrain. An interesting observation made in the case of carrot was that a large percentage of the plants, showing the desirable root characters of the temperate type, flowered and set good seed under Delhi conditions. This indicates that it may be possible to select a new improved type of Asiatic carrot. The F_2 plants raised from the cross, Swiss chard x Spinach bett, flowered profusely. The F_2 seeds will be sown at Delhi and Katrain next season for selecting slow-bolting plants.

For the first time, a small area about 0·2 acre was planted with cauliflower, Snowball—16, for useed multiplication. A good harvest of seed was expected as the weather was favourable during spring and summer.

During the year 1957, 4,367 lbs. of seeds of various summer and winter vegetables were produced at this substation and of this 3,944 lbs. were sold out.

28. *Botanical Substation, Pusa.*

The weather during the year was uncertain and affected most of the crops adversely. The total rainfall was 33·36 inches as against 41·99 inches in the previous year. An unusual heat wave during the months of April, May and June delayed *kharif* sowings and severely affected the *mung* crop.

Work on the improvement of different crops, *viz;* cereals, pulses, oil-seeds, fibres, vegetables and narcotics (tobacco), was continued according to the approved programme. Under the Coordinated Wheat Rust Control Scheme, the wheat breeding work continued to progress. Work was also done on the improvement of some essential-oil bearing spices under an I.C.A.R. scheme. In addition, the Divisions of Chemistry and Entomology were provided facilities for conducting some of their experiments under the local conditions of soil and climate. Seeds of improved N.P. varieties of several crops were multiplied for distribution; a total of 15,584 lb. of seed was distributed. The wheat varieties multiplied on a large scale included N.P. 710, N.P. 718, N.P. 755, N.P. 758, N.P. 761, N.P. 978 and N.P. 799. The work relating to the maintenance of indigenous and exotic collections in several crop plants was continued.

In a small-scale trial of some promising exotic varieties of oates (*Avena* sp), Reed-19, Reed-10 Markton and Iowa-670 again established their superiority. The *mung* (*Phaseolus radiatus*) variety N.P. 23 (control) was found to be the best in trials; the Chinese variety, No. 781, gave a very poor performance as in previous years. Some of the *Khesari* (*Lathyrus* sp.) varieties, such as, the indigenous types, I.C. 76, I.C. 77, and the exotic

varieties, E.C. 4413 and E.C. 1863, have given promising results in regard to fodder yield. The yield trial of five promising exotic varieties of Safflower (*Carthamus tinctorius*) from Nebraska (U.S.A.), with N.P. 30 as control, was conducted for the third year in succession. Although the differences in the yields of these varieties were not significant, some of the Nebraska types, such as, 461, 804 and 852 yielded higher than the control variety N.P. 30. For the third year in succession, the autotetraploid strain of *toria* has yielded higher than the local diploid variety of *sarson*, though not significantly this year. In the yield trial of jute (*Corchorus capsularis*) varieties, the exotic type, E.C. 4142, has again outyielded the rest of the varieties in fibre yield, giving an increase of 136·58 per cent over the control variety, D-154. As for the yield of seed, varieties D-154 (control) and E.C. 4143 continued to give high yields. The exotic variety E.C. 4143, was found to be promising both for the yield of fibre as well as of seed. In a small-scale trial of chilli varieties, N.P. 51 gave the highest yield with an increase of 131:83 per cent. over the control local variety. Some other varieties such as, N.P. 46-A, and N.P. Hyb. 17-1-1 also outyielded the control by about 15 per cent. In a small-scale yield test in tomato, all the nine types extracted from the cross, Sioux x Dickson, outyielded the local variety. Improved Meeruti and Hyb.-12 gave a yield increase of 298·4 and 284·1 per cent respectively over the local variety. In per acre, while the other varieties in the trial, namely, Bonneville, Delwiche Commando, Table-19 and Kanpur-19, gave yields between 3,203 lbs. and 8,712 lbs. per acre.

Programme of work for the year 1958-59.

1. Improvement of Indian wheat with special reference to breeding varieties resistant to the rust, smut and bunt diseases and to drought and lodging.
2. Study of the suitability of N.P. wheats and other breeding material to different agronomical conditions.
3. Genetics of rust resistance and other characters in wheat.
4. Study of the milling, baking and *chapati*-making qualities of Indian wheat.
5. Breeding for rust and smut resistance in barley.
6. Breeding for rust resistance and earliness in linseed and for wilt resistance and earliness in pigeon pea (arhar).
7. Breeding extra-long staple varieties of cotton.
8. Trials with the recently-evolved N.P. strains of crop plants in the different States of India.
9. Trials with foreign varieties and foreign and indigenous inbreds and hybrids of maize on a regional basis in India.
10. Investigations on the utilization of hybrid vigour in various crop plants, including maize, *jowar*, *bajra*, onion, *bhindi*, radish, tomato, brinjal and cotton.
11. Breeding for high yield and early ripening in fodder and grain types of *jowar* and *bajra*.
12. Breeding of some pasture grasses and legumes for northern India, with special reference to suitability to arid, semi-arid and hill regions.
13. Study of the wild relatives of crop plants and their utilization in plant breeding.

14. Improvement of some essential-oil bearing plants, *e.g., cumin,* dill, fennel, coriander and carum.
15. Improvement of chilli, with special reference to the breeding of disease resistant varieties.
16. Breeding of vegetables, including th European-type vegetables, such as, cabbage, cauliflower, turnip, etc. and development of improved methods for the commercial production of quality seed in them.
17. Breeding superior varieties of watermelon and muskmelon.
18. Testing and certification of seeds of vegetable crops.
19. Improvement of ornamental plants by the application of modern techniques like induction of polyploidy and mutations.
20. Study of the genetic variability in Indian algae with a view to their usefulness to agriculture.
21. Induction and study of polyploidy as a method of crop improvement in oleiferous Brassicae, linseed, berseem, etc.
22. Cytogenetical studies in various crop plants, including cotton, oilseeds and millets.
23. Monosomic analysis of rust resistances and other characters in wheat.
24. Cyto-taxonomical and cyto-ecological studies in some Indian fodder grasses.
25. Induction of mutations in crop plants through the use of chemicals and radiations from radio-active isotopes, neutrons, X-rays and ultra-violet rays.
26. Studies on the incidence and induction of pollen sterility in crop plants.
27. Application of embryo-culture technique to overcome embryo lethality in distant crosses.
28. Improvement of cytological technique.
29. Physiological studies on resistance to drought and lodging in wheat.
30. Physiological analysis of factors concerned with yield in wheat
31. Influence of light and temperature on growth and development in wheat.
32. Physiological aspects of plant nutrition in wheat studies on the relation between varietal differences in the uptake of nutrients.
33. Plant-hormones—investigations on their role in growth and development in wheat, cotton, etc. and their use as weedicides.
34. Plant physiological studies in relation to the die-back disease of citrus.
35. Plant physiological studies on colchicine-induced autopolyploids of oil-yielding plants, such as, *toria,* linseed, etc.
36. Plant introduction and exploration for indigenous plants of economic value; their maintenance, evaluation and trials at Delhi and other places.
37. Multiplication and distribution of pure seeds of improved N.P. varieties of field and vegetable crops.

REPORT OF THE DIVISION OF ENTOMOLOGY

(Dr. E. S. Narayanan)

General

A. *Advisory.*—Four hundred and six specimens were indentified and their names communicated to the different correspondents together with the insect specimens wherever called for. Specimens of *Eutermes rubidus* mounted on a slide, were lent to the Forest Research Institute, Dehra Dun, for studies. Advice regarding control of over 15 pests was given to the various correspondents from different states. Leaflets on the biology and control of some insect pests were supplied to correspondents from U.P. Two hundred and seventy coloured plates were supplied during the year to various State Departments of Agriculture & Vigyan Mandir Officers. One thousand three hundred and twenty-three samples of seeds of various crops, 4 varieties of banana suckers, 7 varieties of rose saplings, 4 packets containing cuttings of *Cynodon dactylon* and cuttings of 16 varieties of grapes were examined, treated wherever necessary and health certificates issued.

B. *Donations.*—In all one hundred and eighty-seven identified insects belonging to different orders were donated to Agra College, Agra, Vigyan Mandir Officer, Sehore, M.P. & U.S. Department of Agriculture, through Mr. G. W. Angalet. Fifty thousand *Trichogramma* were sent to the Agricultural Entomologist, Nagpur and 18000, of the same material were sent to the Assistant Entomologist, Central Sugarcane Research Station, Pusa, Bihar. Specimens of the European corn borer *Pyrausta nubilalis* Hubner (only genitalia) and *Heliothis zea* (Boddie) both larvae and pupae were received through the kindness of the U.S. Department of Agriculture.

C. *National Pusa Collection.*—The National Pusa Collection has been augmented through collections made locally from Delhi and also from other parts of India during the tours undertaken by the staff. Over five hundred insect specimens collected have been added to the general collection pending identification during the year. The main identified collection has also been augmented by the addition of thirty species of insects, which were either totally unrepresented or very poorly represented so far.

D. *Check list of Indian insects.*—The preparation of check-lists of Indian insects has been started and so far 498 species of Formicidae, 110 species of Tingidae, 571 species of Jassidae and 658 species of Fulgoroidea have been systematically listed, giving the author's names in full, year in which each was recognised as distinct species, known distribution of each and localities of the holotype wherever known.

E. *Delhi Intensive Cultivation Scheme.*—The staff of the Division continued to survey the crop pests and demonstrate control operations against major insect and other animal pests of agricultural crops. In all about 38·5 acres of crops and 650 fruit and ornamental plants were treated against different insect pests and 523·75 acres against field rats.

RESEARCH PROJECTS

Systematic Entomology

1. *Curculionidae.*—Biometric studies on the sweet Potato Weevil, *Cylas formicarius* F. showed that there existed two different strains of this species, one almost double the size of the other.

2. *Tenebrionidae.*—A taxonomic list of the world genera and a list of the species so far recorded from the Indian region was prepared. The former includes 1207 genera under 85 subfamilies and the latter 447 species systematically arranged.

3. *Ichneumonidae.*—The preparation of a monograph of the Indian species of the subfamily Gelinae on the same lines as the series of the Fauna of India, Burma and Ceylon was in progress.

4. *Chalcididae.*—Preliminary studies of 60 specimens collected so far had shown the common occurrence of three distinct species of Dirhininae at Delhi. The collection and compilation of the existing literature on the subfamily Haltichellinae was nearing completion. Based on the studies of literature and the material examined so far, a key for the separation of the forty-four haltichelline genera hitherto known had been drawn up.

5. *Encyrtidae.*—A list of 153 genera recorded from various parts of the world had been prepared. The following genera were identified from the collection made at I.A.R.I. Estate, New Delhi:—

(1) *Anagyrus,* (2) *Chiloneurus,* (3) *Psyllaephagus,* (4) *Callipteroma,* (5) *Philoponectroma,* (6) *Tetralophidia,* (7) *Cerapterocerus,* and (8) one apparently new, near to *Doliphocerus.* The 5th, 6th and 7th appear to be first records of their respective genera from this country.

6. *Tingidae.*—Over 200 specimens belonging to this family were collected from Delhi and the neighbouring places. Preliminary studies on these showed that all the three known subfamilies, *viz.,* Canthacaderinae, Tinginae and Serenthininae are found in this part of the country. One hundred and ten species of tingids had so far been recorded from Indian region falling under 51 genera.

7. *Neididae (Berytidae of earlier workers).*—A neidid, new to science, was found breeding on the growing tips of the bottle gourd plant in association with *Metacanthus pulchellus* Dallas. The new species had been described as *Metacanthus delhiensis* and compared with its close ally *M pulchellus.*

8. *Fulgoroidea.*—From a perusal of the literature available on this group it was noted that in recent years what Distant considered as a single family, the Fulgoridae, in his Fauna of India, Burma and Ceylon (1906 and 1916) must be looked upon as a superfamily, the Fulgoroidea with as many as nineteen families within it and excepting two of these, the Acanoloniidae and Gengidae, the rest have been recorded from India. Specimens representing the families (1) Cixiidae, (2) Areopidae (= Delphacidae of earlier workers), (3) Dictyopharidae, (4) Meenoplidae, (5) Achilidae, (6) Flattidae, (7) Lophopidae, (8) Ricaniidae and (9) Derbidae had been collected locally from the Estate of the I.A.R.I. during these investigations.

9. *Membracidae.*—A preliminary study of the membracid fauna of the Indian Union had been completed. Five new species, *Tricentrus linearis, linearis, Leptocentrus aeglevorous, L. narayani, L. coimbatorensis and Otinotus tamarixus,* had been fully described. It had also been pointed out that two Indian species placed so far under the genus *Anchon,* viz *A. pilosum* and *A. reticulatum,* were really not congeneric with the type of that genus; for the Indian species a new genus *Anchonomorpha* had been erected. It had also been shown that this genus should fall in a different

tribe, the *Leptocentrini* and not in the tribe to which the real African *Anchon belongs.*

10. *Aphididae.*—A preliminary study of the aphid fauna of the Indian Union was completed. Two new species viz. *Ceratopemphigella delhiensis* and *Brachyunguis calotropicus* and another, *Saltusaphis africana* Estop, first recorded from Africa as late as 1955, were taxonomically dealt with. During these studies it had also been possible to establish the occurrence of fifteen species at Delhi which were additions to the seventeen species mentioned by Gulam Ullah (1940).

INSECT PARASITOLOGY

Fundamental studies

(1) *Effect of nutrition on the fecundity, longevity and sex-ratio of Bracon gelechiae Ashmead and Trichogramma evanescens minutum Riley using Corcyra cephalonica Stainton as their host fed on various synthetic diets:—*

Effect of food on the growth of Corcyra larvae:

The growth of *Corcyra* larvae was studied on the following diets:—

(1) Crushed juar (2) maize flour, (3) maize flour + 5 per cent yeast, (4) maize flour + 10 per cent yeast, (5) maize flour + 20 per cent yeast, (6) a synthetic diet of the following composition:—(i) glucose 50 parts, (ii) casein 50 parts, (iii) cholesterol 1 part, (iv) salt mixture 2 parts, (v) vitamins of group B (a) aneurin, (b) riboflavin, (c) nicotinic acid, (d) p—amino-benzoic acid, (e) pyrodoxin, (f) pantothenic acid each @ 25 p.p.m. of basic diet; (g) choline chloride @ 500 p.p.m. and (h) folic acid @ 2·5 p.p.m. of basic diet.

It was observed that larval growth of *Corcyra* was the best on crushed juar out of the six diets mentioned above.

(2) *Studies on the chalcid egg parasites of Pyrilla perpusilla Walker:—*

(a) *Ecological studies on Tetrastichus pyrillas (Crawford).*—The larval and pupal stages of *T. pyrillae* were exposed to 10 C & 80 per cent R.H. for 11 days, and it was found that these when transferred to 25°C & 80 per cent R.H., there was 20 per cent adult emergence from the pupae so treated while larvae did not give rise to any adult at all. On the other hand, when the larval and pupal stages were kept for 12 days at 10°C & 80 per cent R.H., there was no adult emergence. However, when the immature stages were kept at 35° C for even upto 25 hours, there was 100 per cent adult emergence.

(b) *Embryology of Tetrastichus pyrillae (Crawford).*—Embryological studies revealed that the slightly tapering end of the egg of *T. pyrillae* is directed towards the cephalic end of the female and is definitely the anterior end. Further, it was observed during the development of the egg that the head of the embryo is always formed at the broader, posterior end of the egg. This is a clear exception to the 'law' of Hallez which states that the cephalic pole of the egg is directed towards the head of the female.

(c) *Superparasitism in Tetrastichus pyrillae (Crawford).*—There was no superparasitism when 5 host eggs were exposed to a single female of *T. pyrillae;* but when the number of females was increased to 2, 3, 4, 6 & 8; 4 per cent, 8 per cent, 12 per cent, 24 per cent and 28 per cent of the eggs were superparasitised respectively on an average.

(3) *Studies on resistance to some of the insecticides by beneficial insects (parasites)*

Adults of *Bracon brevicornis* Wesmael were exposed to films of various concentrations of p—p' DDT & lindane at 20°C, 27°C, 30°C & 65 per cent, 75 per cent & 85 per cent R.H. It was observed that the mortality response was higher at higher temperatures and higher relative humidities. The results also showed that resistance was developed more at 75 per cent R.H. than at 65 per cent or 85 per cent.

(4) *Effect of temperature and humidity on the reproductive potential of Apanteles angaleti muesebeck, on endoparasite of the pink bollworm of cotton, Pectinophorn gossypiella (Saund.)*

The fecundity, longevity and percentage of parasitism was studied under combinations of four temperatures viz., 20°C, 25°C, 30°C, 35°C & three relative humidities of 45 per cent, 70 per cent & 90 per cent. The alternate laboratory host was *Corcyra cephalonica* Staint.

(5) *Taxonomy and bionomics of some entomophagous mites.*

Taxonomic studies on certain species belonging to the following genera of mites were completed:—*Leptus, Microtrombidium Erythreaus, Anystis & Paraerythreaus. Anystis* sp. could be reared upto adult stage in the laboratory. It was observed that the eggs were laid in a chain and the female died immediately after ovipositing.

Insect Ecology and Toxicology

(1) *Studies on the development and distribution of insects under different ecological conditions*

Studies on the tolerance of *Trichogramma evanescens minutum* Riley showed that development did not take place when host eggs parasitized by this chalcid were exposed to 45°C & 75 per cent R.H. for 2 hours or more. The data on the construction of Biometer and also the meteorological data for the prediction of the performance of this parasite in different parts of the country were under compilation.

(2) *Studies on population determination and assessment of damage*

Bagrada crucifararum Kirk. successfully completed eight generations on soaked mustard seed during April to November at room temperature in the laboratory. There was 60-70 per cent mortality in the first two instars. The breeding could not be continued successfully at room temperature in winter.

(3) *Effect of chemical control on the biological balance in cultivated crops.*

(a) *Control schedule for mustard crop.*—During the entire season the crop was sprayed two times with different insecticides, *viz.*, .075 per cent + BHC, ·75 per cent, BHC, ·05 per cent basudin, :05 per cent parathion, a mixture of ·1 per cent DDT ·1 per cent BHC (1:1) and :2 per cent nicotine sulphate ·3 per cent emulsifier (teepol 710) and malathion (·05 per cent in the first spraying and ·1 per cent in the second spraying). Parthion treatment showed significantly heavy reduction in the population of mustard aphids in both the sprayings and also significantly raised the yield as compared to the treatments other than the treatment with DDT:BHC mixture. The latter treatment, however, did not effect significant reduction in the aphid population in either of the sprayings.

(b) *Control schedule for maize crop.*—Two sprayings with different insecticides were given against *Chilo zonellus* Swin. and the third spraying was given against aphids. The concentrations of different insecticides used were: ·1 per cent DDT, ·1 per cent BHC, :05 per cent endrin and ·05 per cent systox. During the second spraying concentration of endrin was increased to .1 per cent. The statistical analysis on the reduction of *Chilo* larvae and pupae population after each spraying showed that treatment with BHC in the 1st and 2nd spraying was significant and the per centage reduction was 82·8 and 94·1 respectively. DDT treatment indicated significant reduction in the population in the 1st spraying only. Endrin in the 1st spraying brought about 71·4 per cent reduction but this figure was not found to be statistically significant. Analysis of the percentage reduction in damaged plants after each spraying showed that BHC treatment was significant in reducing the damaged plants in the 1st and 2nd sprayings and treatment with endrin showed significant reduction in the 1st spraying only. Analysis of the yield of maize grain did not show significant differences between the insecticides and the control.

(c) *Effect of endrin sprays on the balance of pest population in cotton crop.*—The spraying of cotton crop with endrin at the rate of $\frac{1}{2}$ to $1\frac{1}{2}$ lb./acre was carried out. Observations after the fifth spraying showed that the population of jassids, thrips, white-flies, mites, aphids and spotted bollworms was reduced by 65 per cent, 91 per cent., 98 per cent., 39 per cent and 99 per cent and 94 per cent respectively whereas that of pink bollworm increased by 19 percent.

(4) *Bioassay of insecticides.*

(a) Earthen pots containing egg pods of 'Phadka' *Hieroglyphus nigrorepletus* Bol. were dusted on the surface with 10 per cent of each of chlordane dieldrin and a mixture of DDT: BHC (1:1) applied @ 40, 50 & 60 lbs./acre. Chlordane was found to be most effective in killing the nymphs hatching out from the egg pods.

(b) Studies on the relative toxicity of eleven insecticidal emulsions used as films with 20 minutes exposure against just hatched larvae of *Pectinophora gossypiella* Saund. showed parathion to be most toxic, followed by endrin, diazinon, malathion, lindane, aldrin, isodrin, dieldrin, DDT, toxaphene, chlordane.

(c) The order of toxicity in the case of *Trogoderma granarium* Everts. adult was found to be : parathion > endrin > dieldrin > gamma BHC > toxaphene > DDT > aldrin > chlordane > isodrin. Against *Oryzaephilus surinamenois* pLinn. dults the order of toxicity was : parathion > DDT > dieldrin > toxaphene > gamma BHC > aldrin > endrin > chlordane > isodrin.

(d) *Trogoderma granarium* grubs were sprayed with 0·125 per cent & 0·25 per cent pyrethrin emulsions with kerosene oil and petroleum ether as bases. Spraying was also done with 0·2 per cent, 0·1 per cent & 0·05 per cent pyrethrin emulsions with only kerosene oil as base. The insecticide was used both singly and in combination with piperonyl butoxide in 1:8 ratio. The experiments were conducted at six controlled temperatures *viz.*, 25°, 28°, 30°, 35° 37° & 40°C. Pyrethrin emulsions in combination with piperonyl butoxide increased the mortality with both kerosene oil or petroleum ether as bases.

(e) Observations made on the fumigation of *Tribolium castaneum* Hbst. in empty space and in presence of barley, maize and juar showed that carbon disulphide was most effective in empty space followed by ethylene dichloride, EDCT mixture and carbon tetrachloride. In presence of commodities the order of toxicity was CS_2 > CCL_4 > EDCT mixture > ethylene dichloride. Further experiments were conducted with carbon tetrachloride in a 100 cu. ft. cement concrete fumigatorium partially filled with 12-13 bags of wheat to test its efficacy against *Tribolium castaneum*, *Rhizopertha dominica* Fabr., *Calandra oryzae* Linn. and *Corcyra cephalonica*. When used @ 10 lb./1000 cu. ft. for 24 hours or @ 7½ lb./1000 cu. ft. for 48 hours, CCl_4 gave almost complete kill of these pests. Eggs, larvae and pupae of *Bruchus chinensis* Linn. in situ were fumigated with CS_2, CCl_4 and ethylene dichloride in 500 ml. flasks. Only CS_2 gave satisfactory results. CS_2 when used @ 20 mg./litre for 24 hours gave complete kill of all the stages. Larvae of *C. cephalonica*, *T. granarium* and adults of *B. chinensis* & *C. oryzae* were fumigated with HCN and the amount of the fumigant sorbed was determined. It was found that *C. cephalonica* larvae were most susceptible followed by *B. chinensis* adults, *T. granarium* larvae and *C. oryzae* adults.

(f) In order to collect data for use in the introduction of plant material *Drosicha mangiferae* Green, adult females, collected from the local mango orchards were fumigated with different fumigants and fumigant mixture for two hours. The order of toxicity based on LD_{50} (mg./litre) of different fumigants was found to be as follows:—

HCN > Methyl bromide > Acrylon > Carbon disulphide > Carbon disulphide + Ethylene dibromide > Carbon disulphide Carbon tetrachloride.

(1.5) (9.3) (38.3) (65.7) (117.2) (235.7)

(5) *Studies on the phytotoxicity of insecticides*:—

(a) About 1½ years old mango saplings were fumigated with acrylon (@ 35, 49, 56 and 70 mg./litre), HCN (@ 0·74, 0·84 and 1·68 mg./litre) and methyl bromide (@ 19·0, 27·2 and 45·1 mg/litre) for two hours to study the tolerance of the saplings to these fumigants. It was observed that both HCN and acrylon, in all concentrations except the lowest, caused phytotoxicity to the saplings.

(b) About 1½ years old mango saplings were sprayed with endrin (0·15, 0·3, 0·5, 1·0 & 1·5 per cent), malathion (0·1, 0·2, 0·4 & 0·75 per cent), gamma BHC (0.5, 1.5 and 3.0 per cent), dieldrin (0.25, 0.5, 1.0 and 2.0 per cent) and aldrin (0.25, 0.5, 1.0 and 2.0 per cent) emulsions to study the tolerance of the saplings to these insecticidal sprays. Except for 0.75 per cent malathion spray which caused slight scorching of the foliage, no phytotoxicity was observed due to any of these treatments.

(c) Studies on the infestation in cowpea (K-397) treated with insecticidal dusts (DDT, BHC & dieldrin) and fumigants (CS_2, HCN & chlorosol) and stored for three seasons at Delhi showed that there was 3·2 per cent to 13·7 per cent infestation in the various dust treatments as compared to 85 per cent in the control. Infestation in fumigated lots ranged from 5·3 per cent to 30·5 per cent. The viability of the seed was not impaired.

Observations in maize yellow No. 2 similarly treated and stored for one season at Delhi, Pusa (Bihar) and Karnal (Punjab) showed that the viability of treated grains was not impaired. The treated seeds from Pusa were further sown in the field to study the development of the plant upto harvest. The plants were healthy and normal in all cases.

Observations in wheat NP-718 similarly treated and stored for one season in different places showed that the infestation in various dust treatments varied from 0·5 per cent to 61·5 per cent as against 34·5 per cent to 84 per cent in the control. The viability of the seeds was not impaired due to these treatments.

Schemes

(A) *Second Five-Year Plan.*

I. *Entomological investigations with the help of radioactive isotopes*:—

When freshly laid eggs of *Bracon gelechiae* Ashmead with host and without host, were irradiated with beta radiations from P^{32} sources of 1600, 800 and 400 mrep/hr. there was no significant effect on the fecundity, viability and development of the insect.

The freshly laid eggs of *Corcyra cephalonica* Stainton were exposed separately for 24 hours to beta radiations from four sources of P^{32} giving dosages of 555, 1111, 2222 and 3333 mrep/hr. respectively. The viability and percentage of successful completion of development of *C. cephalonica* were significantly more in the case of 1111 mrep/hr. dose than in other treatments and the control in the parent generation and the future subsequent generations. In similar experiments with freshly hatched larvae of *C. cephalonica*, the irradiated larvae completed development in all the treatments, but the maximum number of individuals completing the development (85 per cent) was with 1111 mrep/hr. dose. The studies from the first generation indicated that the maximum fecundity (317 per female) was noted in the case of 2222 mrep/hr. dose, whereas the maximum viability (40·9 per cent) was with 555 mrep/hr. dose.

Fate of systemic insecticides in insect body and plants.—The adults of *Dysdercus koenigii* Fab. were continuously exposed to insecticidal films of 'Schradan' on filter papers (1 c.c. of 0·116 per cent., 0·2715 per cent and 0.543 per cent solutions of Schradan) at 30°±2°C. With the

higher dose the mortality was appreciable even after the first day of treatment, but in the case of lower concentrations mortality started from the 5th day of treatment. It was further noted that the lethal quantity picked up from 0·543 per cent. solution by the adults was between $0{\cdot}5518 \times 10^{-5}$ and $0{\cdot}6476 \times 10^{-5}$ mg./mg. of the body weight and was picked up between 18 and 24 hours of exposure.

II. *Biological testing and certification of insecticides:—*

Twenty-five commercial samples of 5 per cent. BHC, 10 per cent. BHC dusts and 50 per cent DDT wettable powder collected from different sources were biologically tested for their toxicity and compared with their corresponding laboratory made formulations. Similar tests were also made with 19·5 per cent endrin obtained in the form of emulsifiable concentrates. *Tribolium castaneum* Hbst. adults were used as test insects.

Eleven samples received from the Division of Chemistry were also tested for their toxicity against *T. castaneum* adults, *Lipaphis erysimi* Kalt., *Schistocerca gregaria* Forsk. and larvae of *Diacrisia obliqua* Walker.

Relative toxicity of some important insecticides to different insect pests was studied. When used as emulsion spray against adults of *Myllocerus maculosus* Desbr., the order of toxicity was: malathion > parathion > DDT > lindane > systox > diazinon > endrin > aldrin. Against the adults of *Aulacophora foveicollis* Lucas, aldrin, dieldrin, lindane, parathion and pyrethrins were found to be more toxic than DDT. In the case of larvae of *Athalia proxima* Klug. the order of toxicity was: parathion > malathion > pyrethrins > endrin > gamma BHC > dieldrin > systox > isodrin > aldrin > niazinon > DDT > chlordane > toxaphene > nicotine sulphate. Against *Locusta digratoria* adults, the order of toxicity was found to be: ethyl parathion > methyl parathion > TEPP > thimet > isodrin > endrin > aldrin > dieldrin > diazinon > lindane > systox > HETP > malathion > chlordane > DDT > toxaphene. Thirteen insecticides *viz.*, toxaphene, isodrin, thanite, BHC, aldrin, DDT, endrin, chlordane, methyl parathion, dieldrin, malathion, diazinon & HETP against *Hypera variablis* Hbst. grubs; 11 insecticides *viz.*, DDT, aldrin, dieldrin, endrin, isodrin, lindane, systox, pestox, malathion, diazinon & parathion against larvae of *Diacrisia obliqua* and 8 insecticides *viz.*, DDT, gamma BHC, endrin, malathion, parathion, diazinon, aldrin and dieldrin against the grubs of *Oryctes rhinoceros* L. were tested for their direct contact effectiveness.

The effect of 16 insecticides, used as emulsion sprays, on grubs and adults of *Coccinella septempunctata Linn.*, a predator of *Lipaphis erysimi* (Kalt.), was studied. As high a concentration as 1 per cent. of each of gamma BHC, pestox, nicotine sulphate, endrin, aldrin, dieldrin, cholordane, toxaphene, DDT, isodrin and HETP gave very low mortality of grubs and adults of *C. septempunctata*. Organophosphorus insecticides like systox, parathion, malathion and diazinon were comparatively more toxic.

III. *Ecological studies on stored grain pests:—*

Studies on the incubation period of eggs, larval period, pupal period and longevity of adults of *Trogoderma granarium* Everts. at 35°, 40° and 45° C and under six relative humidities of 30 per cent., 45 per cent., 60 per cent., 75 per cent., 90 per cent. and 100 per cent. were nearing

completion. Similar studies on the incubation period of eggs and longevity of adults of *Sitotroga cerealella* Oliv. 40° C and under three relative humidities of 30 per cent., 45 per cent. and 60 per cent. were completed.

Experiments carried out with 'alkathene films' showed that given an initial infestation of *Calandra oryzae* followed by chlorosol fumigation and final ventilation, maize could be kept in good condition for 4½ months in an earthen reservoir in which 'alkathene films' were sandwiched in the walls. Some preliminary studies were made on the forced ventilation of wheat in a mud structure of 2x3·5x5 ft. size.

Work was also in progress to study the differential effect of storing wheat NP-718 in (a) mud reservoir, (b) metallic bin and (c) a jute 'theka'.

IV. *Seed Testing*:—

(a) The effect of EDCT mixture on different varieties of summer vegetables like toria, ghia, pumpkin, karela, bhindi and tinda was studied. It was found that the fumigant does not impair the germination of these seeds when used at 4 times the recommended dose.

(b) Susceptibility of nine different types of beans to the attack of *Callosobruchus chinensis* Linn. was studied. The ovipositional response and the effect of these hosts on the subsequent development of this bruchid were also studied.

V. *Locust Toxicology*:—

Single pair rearing of *Schistocerca pgregaria* Forsk. was started in order to obtain a pure culture for experimental purposes. Studies on the relative toxicity of different formulations of insecticidal dusts and sprays on the hoppers of different stages and adults were started.

VI. *Indian Honey Bee*:—

The study of brood rearing cycle of Pusa bees (at Pusa, Bihar) showed that the maximum brood area in a colony was 400 sq. inches during February, which gave a laying capacity of 821 eggs per day during the peak period.

The Pusa bees were found to have an average tongue length of 4·9629 ±0·0041 mm. and 18·25 hooks per wing.

Insect pollinators of 'Saunf' (*Foeniculum vulgare*) included 8 different species belonging to two orders and four families. *Apis florea* F. constituted 81·5 per cent., *A. indica* F. 5·59 per cent., *A. dorsata* F. 1·31 per cent. & syrphidae 6·5 per cent. of the total number of insect pollinators visiting 'saunf'.

Inspect pollinators of berseem (*Trifolium alexandrinum*) included 14 species from ten families of four orders.

VII. *Insect Physiology:—*

Plant Breeding for resistance to insect pests:—

(1) *Effect of nutrients and micronutrients on the metabolism of insect pests of major crops.*—A technique was evolved to rear *Earias fabia* Stoll. in large numbers with less than 40 per cent mortality. *Chilo zonellus* Swin. larvae were reared successfully upto adult stage and *Gnorimoschema operculella* Zell. upto pupal stage on synthetic media.

(2) *Nutrition of insects associated with stored plant products.*—For *Trogoderma granarium* larvae, nicotinic acid, pantothenic acid, choline chloride, riboflavin and thiamin and for *Tribolium castaneum* larvae, nicotinic acid, pantothenic acid and aneurin (thiamin) were found to be most essential. Study of the quantitative requirements of essential vitamins for *Trogoderma granarium* was completed.

(3) *Symbiosis and its physiological significance.*—An exposure of the eggs of *Oryzaephilus surinamensis* to ultraviolet rays of wave length 2,573 brought about the degeneration of symbionts. The symbionts were present in immature stages of *Cletus* sp. but the mycetomes were not clearly demarcated.

(4) *Investigations on the digestive physiology of insects.*—In *Chilo zonellus* larvae food takes about 1·32 hours to travel from one end to the other. Starvation affected the pH of the midgut only at about 72 hours by 0·4 only. In the midgut of *Earias fabia* larvae amylase, maltase, saccharase, lactase, lipase and protease were detected. There was indication of the presence of amylase in the malpighian tubules of *E. fabia* larvae.

(5) *Physiological studies on fruitflies with special reference to nutritional requirements.*—A technique was developed to rear *Dacus cucurbitae* on mass scale in the laboratory on semi-synthetic diet. Luffa-yeast-agar medium proved better than Luffa-agar alone for *Dacus cucurbitae.*

VIII. *Survey of beneficial parasites and predators of pests of agricultural crops in the Indian Union:—*

Twenty-seven species of parasites were bred in the laboratory. Out of these five were new species *viz., Microctonus* sp. nov. from *Phyllotreta cruciferae; Microgaster* sp. nov. from *Adisura atkinsoni* Moore; a species of the subgenus *Lysiphlebus* (genus *Aphidius*) from *Longiungius sacchari* Zehnt.; *Xanthoencyrtus delhiensis* from *Saccharicoccus sacchari* Ckll. and *Microphanurus indicus* sp. nov. from the eggs of a pentatomid bug.

The biology and the morphology of the immature stages of *Microctonus* n. sp., *Xanthoencyrtus delhiensis* n. sp., and *Aholcus euproctidis* Mani were studied.

Mass rearing of hosts and parasites.—About 2 lakh *Corcyra* moths which emerged, laid about 502 cc. of eggs. They were used for the mass-multiplication of *Trichogramma* and other parasites as well as for maintaining the *Corcyra* culture. About 2·06 million adults of *Trichogramma* were bred during the period under report.

(B) I.C.A.R. SCHEMES

I. *Biology and control of termites affecting agricultural crops:—*

(a) Field experiments on the control of termites infesting sugarcane, wheat and cotton; the effect of seed rate on the incidence of termites and the varietal resistance of wheat to termite attack were conducted. The data obtained were being statistically analysed.

(b) Winged form of *Cyclotermes* sp. were collected at night and one pair was introduced in each cage. Eggs were observed after two days. The nymphs hatched after about three weeks. After about a fortnight a few individuals were observed to have chitinised mouth parts. After about sixteen days a tunnel was observed in which workers were moving up and down and a few adults were observed on the surface of the soil. The colony progressed satisfactorily for about 2½ months and then gradually dwindled.

II. *Exploration of toxicity hazards in the use of modern insecticides against cattle and human beings:—*

(a) *Studies on the persistance of DDT residues on stored wheat grains.*—The chemical analysis of grains treated with 10 per cent DDT dust @ 2 oz./125 lbs. of grains at one month interval for six months showed that there was practically no reduction in the residue on wheat stored in glass-jars under laboratory conditions. DDT residues throughout persisted at 57·5 to 78·3 p.p.m. upto six months of storage. Winnowing and washing reduced DDT content to 3·24 to 5·96 p.p.m.

(b) *Studies on hazards due to the residues of insecticides on vegetables, oil seeds and fodder crops.*—Tomato plants were dusted with 2·5 per cent. DDT & 5 per cent. BHC dusts @ 20—25 lbs./acre and also sprayed with 0·2 per cent. DDT & 0·1 per cent. BHC emulsions @ 20—30 gallons/acre for the control of fruit flies. Tomato samples were collected immediately and one week after treatment and analysed before and after washing for the presence of residues of insecticides.

Mustard crop in pre-flowering stage was dusted with 5 per cent. DDT & 5 per cent. BHC against *Phyllotreta cruciferae* Goez. The residues in samples of mustard leaves collected two days after treatment ranged from 5·40—8·64 p.p.m. of DDT & 3·6—6·0 p.p.m. of BHC. Again after one week of dusting, samples were collected and the residues ranged from 4·90—5·80 p.p.m. of DDT & 1·82—2·30 p.p.m. of BHC.

Maize crop was sprayed twice with 0·1 per cent. DDT & 0·1 per cent. BHC emulsion for the control of *Chilo zonellus* till the crop reached the fodder stage. In the fodder samples collected just after the second spraying, DDT residues ranged from 0·11—2·02 p.p.m. & BHC 3·75—6·25 p.p.m. In the samples collected 12 days after treatment showed 0·22—0·56 p.p.m. DDT & 0·6—1·25 p.p.m. BHC. Third spraying was given after the appearance of cobs. Twenty days after this application samples were collected and the residues ranged from 0·31—0·45 p.p.m. DDT & 0.50—0.75 p.p.m. BHC in husk whereas in grains, there was no trace of DDT & BHC contamination.

III. *Biology and nutrition of insect pests of agricultural importance:—*

Effect of various plant products on the growth and development of *Rhizopertha dominica* Fabr., *Latheticus oryzae* Waterh. and *Calandra oryzae* Linn. was studied.

An all amino acid diet was developed for *Trogoderma granarium* Everts.

A new technique was developed for studying the feeding behaviour and biology of *Callosobruchus* sp.

Symbiotes of a number of insects were cultured on artificial media.

DIVISION OF ENTOMOLOGY

PROGRAMME OF WORK FOR 1958-59

A. *Section of Parasitology:—*

1. Effect of nutrition on the fecundity, longevity and sex-ratio of *Bracon gelechiae* Ashmead and *Trichogramma evanescens minutum* Riley reared on *Corcyra cephalonica* St. fed on various synthetic diets.
2. Host selection and distribution of progeny in *Microbracon chinensis* Szep. and *M. brevicornis* Wesm.
3. Studies on coefficient of parasite efficiency of some parasites of cotton bollworm and the root, stem and top borers of sugarcane.
4. Biological control of pink bollworm (*Pectinophora gossypiella* (Saunders) potato tuber moth (*Gnorimoschema operculella*) and *Chilo zonellus* Swinh.
5. Studies on chalcid egg parasites of *Pyrilla perpusilla* Walk.
6. Preparation of catalogues of parasites of pests in Indian Union.
7. *Scheme under the Second Five-Year Plan:—*
   (i) Survey of beneficial parasites and predators of pests of crops in the Indian Union.
   (ii) Effect of selective breeding on *Trichogramma evanescens* Riley.

B. *Section of insect Ecology and Toxicology:—*

1. Studies on the development and distribution of insects under different ecological conditions.
2. Studies on population determination and assessment of damage.
3. Effect of chemical control on the biological balance of cultivated crops.
4. Factors responsible for variation in the susceptibility of insects and the toxicity of insecticides.
5. Bioassay of insecticides.
6. Toxicological and ecological studies on the Desert Locust.

7. Studies on the egect of contact insecticides (DDT, BHC, Dieldrin) and fumigants (CS_2 HCN and chlorosol) on the insect infestation in stored grains and the viability of seeds.
8. Field and laboratory tests with pyrethrins against important crop and stored grain pests.
9. Laboratory tests on the chemical control of the Desert Locust in flight and situ.
10. Oviposition response by the Desert Locust.
11. Phenological observations on crop pests.
12. Plant Introduction.
13. I.C.A.R. Termite Research Scheme.
14. I.C.A.R. Scheme on toxicity hazards of modern organic insecticides to human beings and cattle.
15. Nutritional and biological studies on the insects of agricultural importance.
16. *Scheme under the Second Five-Year Plan:—*
    - (i) Entomological investigations with radioactive isotopes.
    - (ii) Biological testing and certification of insecticides.
    - (iii) Ecological studies on the insect pests of stored grain.
    - (iv) Testing and certification of improved varieties of seeds
    - (v) Bee-keeping.
    - (vi) Locust toxicology.

C *Section of Systematic Entomology:—*

1. Taxonomy of Indian Curculionidae (Coleoptera).
2. Taxonomy of Indian Aeshnidae (Odonata).
3. Studies on Indian Ichneumonidae (Hymenoptera).
4. Review of the Chalcididae (Hymenoptera).
5. Taxonomy of Indian Tenebrionidae (Coleoptera).
6. Studies on *Lasioderma serricorne.*
7. Studies on Indian Tingidae (Heteroptera).
8. Studies on Indian Fulgoridae (Homoptera).

D. *Section of Insect Physiology* (Scheme under the Second Five-Year Plan):—

1. Plant breeding for resistance to insect pests.
2. Nutrition of insects associated with stored plant products.
3. Rearing of beneficial insects including parasites in artificial diet.
4. Symbiosis and its physiological significance.
5. Digestive physiology of insects.
6. Physiological studies on fruit flies with reference to nutritional requirement.

REPORT OF THE DIVISION OF HORTICULTURE

(Dr. S. Krishnamurthi)

The following is a summary of the research work conducted during the year 1957-58 in the Fruit and Vegetable Sections. The work of the Fruit and Vegetable Preservation Section was not started during the year as the technical personnel selected for this Section had not yet joined their posts at the end of the year under report.

A-Pomology (Fruits)

(1) *Survey and collection of superior germ-plasm.*—Several orchards of citrus and mango were surveyed and fifty outstanding trees of different varieties have been marked and 372 plants are being raised vegetatively for further trials at the Institute. Already, 43 plants have been transplanted in the orchard.

A collection of varieties of grapes from several parts of the world including New Zealand, Yugoslavia, Italy, Switzerland and U.S.A., has been built up and the total number of grape varieties now stands at 152. The observations on their growth and performance under Delhi conditions are being recorded, for ultimate selection of high yielding grape varieties suitable for the climate of north India. This is very important considering the loss of our previous grape areas to Pakistan after partition.

(2) *Propagation Studies*:

(a) *Citrus.*—Jullundhuri Khatti (*Citrus limon*) seedlings grown in pots as rootstocks for sweet oranges were sprayed with aqueous solutions of gibberellic acid (GA), when they attained a height of 3 cm. At 100 p. p. m., this compound almost doubled the size of the seedlings as measured by height, indicating the possibility of obtaining buddable size earlier, compared to non-treated seedlings (control). GA had also the effect of very significantly reducing the mortality of seedlings after transplantation, compared to the non-treated (control) seedlings. With GA at 50 p.p.m., the mortality was as low as 9.2 per cent compared to 63 per cent in the control. Such forcing of growth to reduce mortality in transplants and to obtain buddable size in rootstock seedlings earlier would ultimately reduce costs of raising budded plants in citrus.

(b) *Phalsa.*—Among the various methods of propagation tried, inarching and ring budding showed promise and gave a success of 100 and 65 per cent respectively. This is the first time that such propagation methods have succeeded in India and are a definite improvement over the prevalent method of propagation from seed.

(3) *Plant regulator Studies in fruit crops*:

(a) *Grapes.*—The gibberellic acid sprayed in aqueous solution on the seedless grape variety, 'Pusa Seedless' has given very encouraging results. GA at 10 p.p.m., significantly increased the percentage of fruit set from 25 per cent in the control to 44 per cent. GA at 50 p.p.m., increased the average weight of the bunches to 323 per cent of that in the control, and the average weight of individual berries to 139·4 per cent of that in the control without adversely affecting the fruit quality.

The following data summarise the results:—

Treatment	Av. weight per bunch (gm)*	Increase in wt. per bunch over control (%)	Av. weight per berry (gm)**	Increase in wt. per berry over control (%)	Fruit set (%)
GA . . 10 p.p.m.	49·61	19·05	0·85	19·71	43·93
GA . . 25 p.p.m.	88·17	113·99	1·56	119·71	39·62
GA . . 50 p.p.m.	134·66	223·13	1·70	139·43	21·04
Control . .	41·67	..	0·71	..	24·90

*Average of eight bunches.

**Average of 50 berries.

Gibberellic acid sprays were given once at the blossoming time and subsequently 15 days later to the flower clusters. The 'Pusa Seedless' variety has been found to be an excellent seedless grape of high quality and the only draw back is the small size of berries. The possibilities therefore of overcoming this defect so effectively through application of gibberellic acid, are an encouraging feature of the results achieved.

(b) *Guava.*—Sprays of maleic hydrazide (1500 and 2500 p.p.m.) 2,4-D (100 and 150 p.p.m.) and sodium azide (1500 and 2500 p.p.m.) were found to effectively thin the blossoms of the rainy season crop which is generally of poor quality. The chemical sprays were found effective only when applied in the bud stage of the flowers and ineffective after the fruits had set. Success in chemical thinning of flowers in guava may prove to be of value in controlling flowering and fruiting of guava and adjusting fruit-harvests to profitable seasons.

(c) *Phalsa.*—A large number of plant regulators like NAA, 2, 4-D, GA, p-chlorophenoxyacetic acid (ClPA), a-O-chlorophenoxypropionic acid, 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T), and 2, 4, 5-trichlorophenoxypropionic acid (2, 4, 5-TP) were applied as aqueous sprays at various concentrations to the flower at full bloom of phalsa. Gibberellic acid (10 p.p.m.) gave the maximum increase in fruit set raisng it to 64 per cent compared to 47:5 per cent in the control. As the concentration of GA was further increased, the increase in fruit set was progressively reduced. The maximum increase in yield was obtained through GA at 40 p.p.m. which gave 19 per cent increase over the control. 2, 4, 5-T (5 p.p.m.) induced the highest percentage (30.7 per cent) of total soluble solids compared to 24·9 per cent in control.

(d) *Strawberry.*—Applications of gibberellic acid (GA) and p-chlorophenoxyacetic acid (ClPA) to strawberry showed some promising results as would be evident from the data given below.

Treatment		Av. height of plants (cm.)	Av. length of peduncle (cm.)	Av. No. of flower buds per plant	Av. total yield per plant (gm)	% increase in yield per plant over control
GA	5 p.p.m.	13·2	10·5	29	38·39	48
GA	10 p.p.m.	16·9	18·0	47	42·07	62
ClPA	5 p.p.m.	8·7	9·0	27	30·67	14
ClPA	10 p.p.m.	9·2	9·5	30	34·01	31
Control		8·0	6·0	24	25·90	..

The GA sprays increased the height of plants and length of peduncle significantly over the control and ClPA sprays. Sprays with ClPA (5 and 10 p.p.m.) also increased the height, to a lesser extent over the control. A similar trend was observed regarding the length of the peduncle. It is interesting to note that GA 10 p.p.m. increased the fruit bud formation in strawberry significantly over all other treatments, including the control.

The GA spray at 5 and 10 p.p.m. increased the total yield per plant by 48 and 62 per cent respectively over the control. Spray with ClPA at 5 and 10 p.p.m. also increased the total yield per plant by 14 and 31 per cent respectively. It is, however, clear that GA spray, when used at the same concentrations as of ClPA were much more effective in increasing the total yield.

(4) *Breeding superior varieties in fruits*:

(a) *Improvement of grapes with special reference to earliness, yield and fruit quality.*—Of the 152 varieties of grapes collected from within the country and abroad, 17 varieties came to fruiting during this year and a detailed study was made of their fruiting behaviour and quality etc. The varieties Kandhari, Bhokri, Alamwick, Hur and Fakhri ripened by the first week of June and the varieties Pusa Seedless, Black Muscat, Black Prince, Gros Colman, Habshi, Bharat Early and Black Hamburg ripened by the 15th of June, indicating the utility of these varieties under Delhi conditions by fruiting prior to the onset of monsoon. This is an encouraging feature of the work on grapes at I.A.R.I. The varieties Hussaini, Tas, Golden Queen, Bangalore Blue and Rosem-T—Lahore matured during the first week of July.

The seedless variety known as 'Pusa Seedless' was found to be a particularly excellent variety. The variety bears medium to heavy crop when trained on a pergola. The bunches are medium in size; berries are short-oval, green to yellowish green in colour, with 20 to 22 per cent of total soluble solids and superior taste and flavour. This variety selected by the Horticulture Division promises to be worthy of recommendation for a wider extension.

The seeded varieties, alamwick, Black Muscat, Fakhri, Habshi, Hur and Kandhari were also found to be of good quality.

(b) *Improvement of citrus through isolation of superior bud mutations.*—An interesting bud mutant with nearly seedless fruits was observed on a grapefruit tree of Foster variety which is normally highly seeded in the orchards of the Horticulture Division. The quality of the fruits from the new bud mutant also compared favourably with the Marsh Seedless—a leading commercial variety. This is further being propagated vegetatively for testing its possibilities of success as a commercial variety.

(5) *Cytological and cytogenetical studies*:

(a) *Cytogenetical studies in pomegranate.*—Pioneering work on the cytological investigations on the causes of sterility noted in various varieties of pomegranate is under way. Techniques for cytological examination of this difficult material were standardised. The chromosome number of variety Double Flower was found to be 2n=18 and in other varieties like Dholka, Muscat White, Kandhari and Patiala, the chromosome number was 2n=16.

(b) *Induction of polyploidy in grapes.*—Investigations on the induction of polyploidy in important grape varieties *viz.*, Bhokri, Black Muscat, Black Prince, Kandhari, Habshi, Hussaini, Fakhri, Alamwick and Anab-e-Shahi by colchicine treatment were continued during the year. About 220 plants in the nursery and 6 in the field were treated with colchicine (0·5 per cent). The probable autopolyploids were identified by their morphological abnormalities and stomata size and 200 of these plants were transplanted in the field. Observations on the size of the berries and quality will be started as soon as the treated plants start bearing. The chromosome numbers will also be determined. Apart from these abnormalities, a teratological character was observed in the treated plant of the variety Habshi. Such an abnormality, either of spontaneous or of induced origin, has not been recorded so far in grape. Three distinct leaves emerged in a shoot which developed from a treated bud. Such an abnormality is called pleiophylly a teratological character.

B—VEGETABLE SECTION

1. *Survey and collection of indigenous and wild species and varieties of vegetables and assessment of variability in them and their utilization for breeding.*

About 440 strains of different vegetables were collected from different States. This collection also included some wild species of tomato. Each strain was sown in non-replicated rows and its characters are being assessed. The main characters studied are shape and size of fruit, maturity period, height of the plant, yield, diseases and pest resistance, etc.

The survey work could not be taken up as no research staff except the Vegetable Breeder was recruited. The objective of this survey and collection is to collect varieties with good fruit quality, high yield, disease and pest resistance, early, midseason and late maturity, etc.

2. *Studies on Sex-ratio in Cucurbits.*

(a) *Cucumber* (*Cucumis sativus*).—A trial was started in February, 1958 to study the sex-ratio of six varieties of cucumbers. The observations were completed in 1958. The seeds of four varieties were obtained from the Division of Botany, I.A.R.I. and those of the other two varieties from a private seed nursery. The seeds were all reported to be pure lines. The trial was laid in randomised replicated plots to avoid the heterogenity of the soil fertility, which also has been found to affect the sex-expression of certain plants. There were four replications with three plants in each replication. The number and sex of flower at each node of each plant were noted. The varieties under study were Straight Eight, A & C, China, Fordhook's Famous, I.C. 4079 and Khira Poona. The meteorological data, the day length and the temperature during the period of study were also noted.

The following were the number of female and male flower and the female to male flower ratio recorded.

S. No.	Variety	No. of female flower per plant.	No. of Male flower per plant.	Ratio of female to male flower per plant.
1	A & C	68	1063	1 : 15·632
2	Straight Eight	76	493	1 : 6 ·486
3	China	19	697	1 : 36·684
4	Fordhook's Famous	28	361	1 : 12·892
5	Khira Poona	17	35	1 : 2·058
6	*I.C. 4079	7	40	1 : 5·714

*Due to the total failure of germination this variety was resown after a fortnight and as such flowering started about twenty days later than other varieties. The plants withered at the same time as others.

Trimonoecious plants were recorded in the varieties Fordhook's Famous and China. The ratio of flowers on these plants were as follows:—

Fordhook Famous . ♀: ♂: ♂+ = 1:15.5: 0·6

China . . . ♀: ♂: ♂+ = 1:22.2: 0.38

All the varieties were selfed to continue the study in the next season.

The object is to select varieties with high female to male flower ratio and good fruit yield.

3. *Studies on the chemical induction of male-sterility and suppression of male flowers in Cucumber.*

A preliminary study was conducted in July to September 1957 on the chemical induction of male sterility and suppression of male flowers in cucumber. Quite encouraging results were obtained with maleic hydrazide and naphthaleneacetic acid. In February, 1958 a detailed study was started in a randomised replicated plots. Four chemicals, *viz.,* maleic hydrazide (200, 400, 600 and 800 p.p.m.), naphthaleneacetic acid (100 and 200 p.p.m.) indoleacetic acid (100 and 200 p.p.m.) and 2, 4-dichlorophenoxyacetic acid (5 and 10 p.p.m.) were sprayed first at one-to two-true leaf stage and then again at four to five-leaf stage.

The following percentages of pollen sterility were observed:—

MH 200 p.p.m.—11	NAA 100 p.p.m.—33	2,4-D-5 p.p.m. 0·5
MH 400 p.p.m.—14	NAA 200 p.p.m.—41	2,4-D-10 ,, 5·5
MH 600 p.p.m.—15	IAA 100 p.p.m.—6	Control (No spray) 0·5
MH 800 p.p.m.—60·5	IAA 200 p.p.m.—8	

No abnormality was observed in the morphology of the petal or the fertility of the female part of flowers.

There were definite indications of the suppression of male flowers and forcing up the number of female flowers.

The following numbers of female and male flowers and their ratios were recorded:—

Treatment	No. of female flowers per plant.	No. of male flowers per plant.	Percentage of female flowers per plant.	Ratio of female to male flower per plant.
MH—200 p.p.m.	70·50	387·25	15·401	1 : 5·499
MH—400 p.p.m.	26·75	262·00	9·264	1 : 9·794
MH—600 p.p.m.	48·00	512·50	8·563	1 : 10·678
MH—800 p.p.m.	24·00	296·50	7·488	1 : 12·361
NAA—100 p.p.m.	71·75	284·25	20·154	1 : 3·940
NAA—200 p.p.m.	51·75	269·50	16·109	1 : 5·208
IAA—100 p.p.m.	61·75	496·25	11·066	1 : 8·036
IAA—200 p.p.m.	48·25	291·75	14·191	1 : 6·036
2, 4-D-5 p.p.m.	59·25	478·75	11·013	1 : 8·080
2, 4-D-10 p.p.m.	43·25	402·75	9·690	1 : 9·312
Control (no spray)	52·50	508·00	9·360	1 : 9·676

MH 800 p.p.m. had a stunting effect on the plants. The apical dominance was suppressed and some side branches were induced from the lowest nodes. The female to male flower ratio was quite high in the first few weeks but later the number of male flowers increased and that of female flower decreased. The trial will be repeated with more number of treatments.

4. *Studies on the effect of plant regulators in destruction or interruption of apical dominance.*

Cowpea (*Vigna Sinewis*).—It has been noticed that by reducing or destroying the apical dominance in certain plants development of lateral snoots is attained. It has also been reported that increased yield may be obtained by spraying certain chemicals which induced effects associated with the loss of apical dominance. With these objectives in view, a preliminary study was conducted to see the effect of different concentrations of maleic hydrazide (MH) on the interruption or destruction of apical dominance in cowpea. The concentrations of MH used were 200, 400, 600 and 800 p.p.m. The following results were recorded.

The apical dominance was suppressed with all concentrations. There were more side branches in the treated plants and they had a bushy character. Lower concentration of MH (200 p.p.m.) increased the total yield over control. Higher concentrations of MH seemed to have toxic effect and the yield decreased with the increase in concentration. The maturity of pod was delayed with the increase in concentration. The yield data per plant is given below:—

A detailed study with more number and concentrations of chemicals will be carried during the next season.

Treatment	Yield of pods per plant.
Maleic hydrazide —200 p.p.m.	50
„ „ —400 p.p.m.	29
„ „ —600 p.p.m.	20
„ „ —800 p.p.m.	17
Control (no spray)	30

b. *Studies on the effects of plant regulator sprays on fruit-set.*

Tomato: (*Lycopersicon esculentum* Mill.).—It has been observed that due to unfavourable weather conditions fertilization fails in early and late inflorescences of tomato and there is no fruit set. A trial was conducted to study the effect of six plant regulator sprays at different concernntrations on fruit set in two varieties of tomato, namely, Sioux and Pusa Ruby. The objective was to get early fruit maturity and higher yield. The trial was laid out in two sets in randomised replicated plots. The first set was flower cluster spray, in which first four to five flower clusters were sprayed and the second was whole plant spray.

In the whole plant sprays, there were some morphological modifications of leaves and flowers. With p-chlorophenoxyacetic acid (CLPA), the leaves became narrow and elongated and the flowers were bigger. 2, 4-D, affected the leaves only—they were narrow and thick with more prominent veins. The intensity of these effects slowly reduced and later growths were normal. Parthenocarpic fruits were induced with CLPA, 2, 4-D and BNA.

The yield data presented in the table show some varietal response to different plant regulator sprays. The flower cluster spray gave highly significant results. In the variety Sioux, CLPA (25 p.p.m.) gave significantly higher yield than control. In the variety Pusa Ruby, IAA (100 p.p.m.) gave significantly higher yield than other treatments and was followed by CLPA (25 p.p.m.). In the whole plant spray, the statistical calculation was not feasible as large number of plants were affected by necrotic virus. The trial will be repeated next season. However, the following indications have been recorded. In the variety Sioux, IAA (25 p.p.m.) gave the highest yield followed by BNA (25 p.p.m.) and in the variety Pusa Ruby, IBA (25 p.p.m.) gave the highest yield followed by IAA (50 p.p.m.). The trial is to be repeated next season for confirmation of results.

Variety-Sioux. Treatment	Mean Yield in lb.	Variety-Pusa Ruby Treatment	Mean Yield in lb.
CLPA 25 p.p.m.	2·08	IAA 100 p.p.m.	2·25
NAA 100 p.p.m.	1·85	CLPA 25 p.p.m.	1·92
Control (water spray)	1·85	2, 4-D 5 p.p.m.	1·75
IBA 100 p.p.m.	1·29	NAA 50 p.p.m.	1·72
IAA 100 p.p.m.	1·26	IAA 50 p.p.m.	1·66
Control(no spray)	1·22	Control (water spray)	1·59
2, 4-D 10 p.p.m.	1·21	CLPA 50 p.p.m.	1·53
IAA 50 p.p.m.	1·20	2, 4-D 10 p.p.m.	1·52
2, 4-D 5 p.p.m.	1·19	IBA 50 p.p.m.	1·44
NAA 50 p.p.m.	1·01	BNA 50 p.p.m.	1·38
BNA 100 p.p.m.	1·00	IAA 100 p.p.m.	1·28
CLPA 50 p.p.m.	0·98	NAA 100 p.p.m.	1·09
IBA 50 p.p.m.	0·86	Control (no spray)	1·09
BNA 50 p.p.m.	0·83	BNA 100 p.p.m.	1·04
$SE_m = \pm 0·246$		$SE_m = \pm 0·031$	
C.D. at 5%-0·715		C.D. at 5% = 0·064	

General

Advisory work and distribution of pedigree fruit grafts and seeds of flowering annuals and vegetables continued as in previous year.

Collaboration with other research institutions in India and abroad continued in regard to exchange of information, seeds and planting materials.

Steps were also taken to establish a museum and a herbarium in the Division of Horticulture. Already fruits of large number of temperate fruit varieties have been collected and preserved in museum jars and several herbarium sheets, of rare and common species of ornamental trees, shrubs etc., have been prepared.

RESEARCH PROGRAMME FOR THE YEAR 1958-59

I. Pomology Section

1. Survey, collection and evaluation of superior germ plasm in mango, citrus, guava and grapes.
2. Fruit tree propagation and standardization of rootstocks in citrus, mango, guava and phalsa.
3. Effect of plant regulator sprays on the vegetative growth, cropping and fruit quality of guava, grapes and on male sterility in papaya.
4. Improvement through hybridization of grape with special reference to earliness, yield and fruit quality.
5. Improvement of guava by selection and hybridization with special reference to yield and fruit quality.
6. Improvement of Citrus fruits through bud mutations.
7. Induction of mutations in Citrus through X-rays, fast neutrons and radio-isotopes.
8. Cytological study of pomegranate varieties (*Punica granatum*) with special reference to the problem of sterility.
9. Induction and utilization of polyploidy for the improvement of grapes with special reference to seedlessness and other desirable qualities.
10. Survey and collection of garden tools and implements from different States and their improvement.
11. Studies on taxonomy and performance of tropical and sub-tropical fruit varieties under Delhi conditions.
12. Improvement of mango by selection and hybridization.
13. Studies on irregular bearing in mango.
14. Studies on intercropping, covercropping and mulching of young sub-tropical fruit plantation.
15. A survey of the varietal situation in fruits in the Delhi market.

II. Vegetable Section

1. Survey and collection of indigenous and wild species and varieties of vegetables and assessment of variability in them and their utilization for breeding.
2. Breeding early mid-season and late varieties.
3. Studies on sex-ratio in cucurbits.
4. Studies on the pollination with special reference to insect pollinator in brinjal and lady's finger.
5. Studies on intra-sterile and inter-fertile lines and inheritance of characters and their linkages in early cauliflower, turnip (Asiatic) and radish (Asiatic).
6. Studies on the economics of vegetable seed production.
7. Studies on the effect of chemical sprays on induction of male-sterility and suppression of male flowers in cucumber.
8. Studies on the effect of plant regulator sprays on the interruption or destruction of apical dominance in cowpea.
9. Studies on the effect of plant regulator sprays on fruit-set in tomato.

(Head of the Division of Horticulture.)

REPORT OF THE DIVISION OF MYCOLOGY AND PLANT PATHOLOGY

(R. S. VASUDEVA)

A. *Section of Plant Pathology*

1. *Wheat* (*Triticum aestivum* L.):

(a) *Rusts* [*Puccinia graminis tritici* (Pers.) Erikss. and Henn, *P. triticina* Erikss. and *P. glumarum* (Schmidt) Erikss. and Henn.]:—For physiologic race study, 421 rust samples, obtained from different parts of the country, were analysed and races 15, 15-C, 17, 21, 21-A, 21-B, 24, 34, 40 and 42-B of black rust, races 10, 11, 17, 20, 26, 63, 70, 77, 106, 107, 108 and 162 of brown rust and races 13, 19, 20, 31, 'A' and 'G' of yellow rust were encountered. Biotype 21-B of black rust was isolated from the collections of 1956-57 crop and was found to be more virulent than races 21 and 21-A when compared on a number of exotic varieties. Race 162 of brown rust, which had been first picked up during the last year, was again observed this year. Races 42-B, 21 and 40 of black rust, races 20, 77 and 107 of brown rust and races 19, 'A', 31 and 'G' of yellow rust were predominant and widely distributed throughout the country, while races 17 and 162 of brown rust and biotype 21-B of black rust, first isolated from 1956-57 crop, appeared to be increasing in frequency. The virulent race 122 of black rust, which had not been encountered during the last two years, was picked up during this year's analysis.

Surveys in the upper Simla Hills (above 7,000 ft.) again showed the presence of the three rusts of wheat on self-sown wheat and barley plants all the year round. Survey of Nilgiri Hills during winter months showed heavy infection of brown rust on local wheats, while that of black and yellow rusts was comparatively less. Further evidence of oversummering of yellow rust on *Muehlenbergia hugelii* in Himachal Pradesh was obtained.

Out of 34 species of grasses, belonging to 16 genera, 9 species, which had been found to be susceptible in earlier tests, were re-tested with one or more rusts. Four species of *Aegilops* (*A. bicornis, A. triaristata, A. ovata* and *A. squarrosa*) were found to be susceptible to the three rusts of wheat, but resistant to black rust of oats, whereas *Phalaris canarensis* and *Avena glauca* showed the reverse reaction. In addition, *Agropyron triticeum* was found to be susceptible to black and yellow rusts of wheat and black rust of oats, but resistant to brown rust of wheat. Furthermore, 23 other species of *Agropyron* and *Aegilops* were tested with races 15-C and 122 of black rust of wheat *Agropyron ciliare, A. longiaristatum, A. triticeum, Aegilops columnaris, A. triuncialis* and *A. turcomanica* (with awns) were found to be resistant to both the races, while *Aegilops squarrosa* and *A. variabilis* to race 122 and *Aegilops caudata, A. ovata* and *A. umbellulata* to race 15-C only. Natural infection of black and yellow rusts on a number of species of *Agropyron* and *Aegilops* was also observed.

In alternate host studies, seedlings of wheat and *Agropyron* were inoculated with aecia collected from naturally infected *Berberis* spp. under glasshouse conditions, but infection could not be obtained in spite of the fact that aeciospores were viable. Hybridization studies between black rust of *Agropyron semicostatum* and black rust of wheat (races 21 and 42) were in progress.

More than 20,000 seedlings of wheat varieties, crosses and progenies were tested in the seedling stage either with individual races of the three rusts of wheat or their mixtures. Wheat variety E. 3123 was found to be resistant to all the individual races of black rust and varieties E. 2125 and E. 3099 to all the individual races of brown and yellow rusts, respectively. In the tests with the mixtures of races of individual rusts, wheat varieties E. 2733, E. 2837, E. 3098, E. 3158, E. 3176 and E. 3236 were found resistant to black rust; E. 2733 and Hyb. 177-3-1 to brown rust; and E. 976, E. 2096, E. 3066, E. 3067 and E. 3076 to yellow rust.

A large number of wheat varieties, crosses, fixed hybrids and other material were tested in the adult stage for their resistance to the three rusts of wheat by creating artificial epidemic in the field. An area of about 5 acres was inoculated with a mixture of all the races (except race 122 of black rust) of the three rusts and good infection was obtained. Observations were taken on about 100,000 single plants and promising material was selected in collaboration with the Division of Botany. Adult plants of wheat varieties *Triticum vavilovi, Motia, Katia* and *Malvi local* were inoculated with all the individual races of all the three rusts separately under glasshouse conditions to test their suitability as infector varieties for field trials and varieties *Motia* and *Triticum vavilovi* were found to be the most suitable varieties for black and brown rusts, respectively.

Studies on survival of races 21 and 40 of black rust of wheat in mixture on wheat varieties *Agra local*, Pb.C. 591, NP. 4, N.P. 710 and N.P. 718 were continued and the relative proportion of the two races upto 9th generation was determined. It was found that race 40 increased in proportion as compared to race 21 on N.P. 4, N.P. 718 and Pb.C. 591, whereas in the case of N.P. 710 the position was just the reverse. On *Agra local*, however, there was no change in the proportion of the two races.

Comparative studies of different races of black rust of wheat showed that race 75 had longer incubation period than other races by 5-6 days at 20°-25° C., while race 34 produced smaller uredospores by about 3 microns. Two colour mutants of race 194 of black rust of wheat were isolated. Also, indications of a third mutant in the same race were obtained.

(b) *Loose smut* [*Ustilago tritici* (Pers.) Rostr.]:—Out of 48 wheat varieties tested for their resistance to the disease under field conditions at Delhi, 21 remained free from infection. Amongst the smut-free varieties, E. 581, E. 2025 and E. 2140 have consistently remained free from infection during the last three tests. In similar tests at Simla with 46 wheat varieties, 33 remained free from infection, of which varieties E. 581, E. 875, N.P. 768, N.P. 783, N.P. 789 and N.P. 809 have consistently remained free from infection during the last three years. Infection obtained in some of the susceptible varieties was as high as 72—100 per cent at Delhi and 32·7 per cent at Simla.

Work on the selection of resistant sub-strains within the highly susceptible variety N.P. 775, which otherwise shows desirable agronomic characters, was in progress and, in this connection, 17 single plant selections (showing less than 10 per cent infection), out of 250 under test this season, were re-inoculated. In addition, 322 plants of B3 families and 68 promising plants of B2 selfed—1 inoculated families of the crosses N.P. 775

x N.P. 790, N.P. 775 x N.P. 798 and their reciprocals as also promising plants of F3 families of the crosses N.P. 775 x N.P. 798 and N.P. 775 x N.P. 798 were inoculated with the pathogen.

Of the 17 wheat varieties inoculated for selecting suitable differentials for loose smut, 6 varieties were rejected as they did not show any differential reactions when tested with 10 isolates of the pathogen. The remaining varieties were re-inoculated with different isolates for further selection next year.

(c) *Karnal Bunt* [*Neovossia indica* (Mitra) Mundkur] and *Hill Bunt* [*Tilletia caries* (DC). Tul. and *T. foetida* (Wallr.) Liro]:—Out of 162 wheat varieties inoculated for varietal resistance tests under field conditions at Karnal and in pots at Delhi with the sporidial suspension of *Neovossia indica*, both by the Hypodermic syringe method in boot-leaf stage and Moore's Partial Vacuum method at mid-anthesis stage, 131 varieties remained free from bunt infection. The maximum infection obtained in susceptible varieties was 33·3 per cent on ear basis and 23·5 per cent on grain basis. This low percentage of infection was apparently due to low humidity (49—70 per cent) and high temperature (25—30° C.) prevailing at the time of infection. However, in an experiment to determine the optimum conditions for the infectivity of the pathogen, 100 per cent infection was obtained in N.P. 165 when the inoculations were made between 21-11-57 and 25-11-57 in boot-leaf stage. Furthermore, effect of cow dung extract and different chemicals as also of carbon and nitrogen sources on chlamydospore germination was studied. Maximum germination (54—58 per cent) was obtained in cow dung extract (N/20), while the untreated chlamydospores showed only 20—27 per cent germination.

In the varietal resistance tests against Hill bunt (*Tilletia foetida*) with 110 wheat varieties, 13 (E. 189, E. 192, E. 201, E. 2327, E. 2469, WR 66, WB 2, WB 85, WB 86, WB 87, WB 93, WB 113 and Australian 1) reacted as resistant. E. 2327 and Australian (1) have been consistently found to be resistant during the last 3 years' tests. These have also proved resistant to *T. caries* in this year's test at Simla (6,300 ft.) and could, therefore, be considered as Bunt-resistant and utilized as sources of resistance for future breeding programme. In addition, E. 192, E. 197, E. 201 and WB 94 appeared to be promising against *T. caries*. For physiologic race study, 22 samples of *T. foetida* and 10 of *T. caries* (including five samples each from previous two years' tests) were analysed this year on standard differentials and indications of the presence of 10 races of *T. foetida* and 6 of *T. caries* were obtained. In host-range studies, *Triticum dicoccoides*, *Aegilops ventricosa*, *A. cylindrica*, Lyallpur Rye and *A. crassa* were successfully infected with *T. foetida*. Also, it was found that *T. foetida* spores lost their viability before the next sowing season when the bunted ears were left exposed on the surface of soil or buried therein, whereas bunt spores on wheat seed, kept at room temperature (16°—25°C.), remained viable for more than 3 years. Artificially infected wheat seed, exposed to temperatures ranging from 25° to 65°C. for 24 hours, showed that 5 per cent of the spores were viable even at 50°C., but this temperature adversely affected the germination of seeds. Sowings done at weekly intervals from 28th September to 28th December, 1957, indicated that the maximum infection was obtained when the sowings were done in the last week of November and first week of December. It was further observed that infection progressively

increased with the increase in depth of sowing and with the increase in spore load used. For example, spore load of 0·025 to 2·5 gms. per 100 gms. of wheat seed gave increase in infection from 2·4 to 90·2 per cent.

(d) *Powdery mildew* (*Erysiphe graminis tritici* El. Marchal):—Freshly collected conidia of the pathogen germinated and caused host infection between 0—25 C. and 0—100 per cent relative humidity, the optima being 15—20°C. and 100 per cent, respectively. There was a direct correlation between temperature and humidity for infection. At 0°C., conidial germination and host infection took place in the absence of film of water, whereas at higher temperatures almost 100 per cent humidity was required. Optimum infection was obtained at moderate light intensities and very weak in total darkness. Young seedlings were more heavily infected than older plants. Furthermore, detached conidia lost their viability within 24 hours at room temperature during the winter months under Delhi conditions, but the culture remained viable on the host under glasshouse conditions even when the temperature ranged from 22° to 27°C.

Out of 26 wheat varieties tested for their resistance to the disease, Khapli was found to be immune, while Vernal and Einkorn were resistant. In host-range studies with 24 grass species, light infection was obtained on *Avena glauca, Lolium temulantum* and *Aegilops* sp.

2. *Barley* (*Hordeum vulgare* L.):

(a) *Rusts* [*Puccinia graminis tritici* (Pers.) Erikss. and Henn., *P. giumarum* (Schmidt) Erikss. and Henn. and *P. hordei* Otth.]:—Twenty-four samples of black and yellow rusts, collected from different parts of the country, were analysed and races 15, 21, 34, 40 and 42-B of black rust and races 19 and 'G' of yellow rust were met with. In the seedling resistance tests, 3,368 seedlings were tested with individual races of black and yellow rusts or a mixture of races of individual rusts. Barley varieties B. 267, B. 241 (Simla) and N.P. 4 (Simla-1) were found to be resistant to individual races of yellow rust, while BH. G-2-3 pl. 9, BH. 4-2-4 pl. 23 and BH. 4-2-7 pl. 3 to a mixture of the races. None of the varieties tested was resistant either to the individual races of black rust or to their mixture. In the adult resistance tests, about 20,000 plants, comprising varieties, hybrids and their progenies, were tested in field against black and yellow rusts after creating artificial epidemics and the promising material was selected.

Leaf rust of barley (*Puccinia hordei* Otth.) was again observed during this year in a severe form and observations were taken on 400 barley varieties under natural conditions of infection. One hundred and sixty-two varieties showed infection ranging from traces to moderate, while varieties B. 222, B. 223, N.P. 13 and N.P. 21 were heavily infected. Eight rust samples, collected from Bihar, Delhi and Madras, were analysed and a new race was isolated. Thus, 2 races, provisionally designated as H1 and H2 (new race), and a biotype of the former have so far been picked up.

(b) *Loose smut* [*Ustilago nuda* (Jens.) Rostr.]:—Of the 31 barley varieties tested for their resistance to the disease under field conditions, only B57(S) remained free from infection. In some of the susceptible varieties, infection as high as 88 per cent was obtained.

(c) *"Molya" Disease*:— A detailed survey of the disease in district Sikar of Rajasthan was undertaken and a large number of soil and root samples from disease infested and apparently healthy areas were collected. Analysis of these samples clearly showed that a species of *Heterodera* was closely associated with the disease. The pathogenicity of this nematode on wheat and barley plants was established under glasshouse conditions, and it was found that temperature of 20°—22°C. was most favourable for this purpose. A number of fungi, which included species of *Fusarium, Helminthosporium, Pythium* and *Rhizoctonia*, were also isolated from the roots of diseased wheat and barley plants and the role of these fungi in the development of the disease is being studied.

3. *Maize (Zea mays* L.):

Rust (*Puccinia sorghi* Schw.):—Fifteen rust samples, collected from Punjab, Himachal Pradesh and Nilgiri hills during 1956-57, were tested on 35 inbred lines of maize, but no further evidence of physiologic specialization within the pathogen was obtained. Of the four species of *Oxalis* (*O. corniculata, O. acetosella, O. pubescens* and an unidentified one) inoculated with the germinating teleutospores of *Puccinia sorghi* under glasshouse conditions, only *O. corniculata* got infected, thus establishing it as the alternate host of the rust. The actual role of this weed in the perpetuation of the rust under natural conditions is, however, being studied.

4. *Bajra* (*Pennisetum typhoides* Stapf and Hubbard):

Green-ear disease [*Sclerospora graminicola* (Sacc.) Schroet.]:—In the experiments conducted to induce quicker and better germination of oospores of *Sclerospora graminicola*, maximum germination was obtained when the material was buried in the field. Other treatments like alternate drying and wetting, exposure to different temperatures (8°—40°C.) and soaking in *bajra* leaf decoction, dung extract, dilute cattle urine, citric acid and nicotinic acid did not accelerate germination.

5. *Sugarcane (Saccharum officinarum* L.):

(a) *Red Rot* (*Colletotrichum falcatum Went*) -During the year under report, Red Rot appeared in the form of localised epidemics in a few villages of Delhi State and the cane variety affected was Co. 312. Isolations from the diseased canes, collected from these localities, yielded light type isolates of *C. falcatum.*

The comparative virulence of 31 selected isolates of *C. falcatum* (5 dark and 26 light types) was tested on the ten standard cane varieties. Obvious differences in the virulence of various isolates were observed Generally, the light type isolates were more pathogenic than the dark ones. Of the isolates tested, No. 390 (a light type isolate), recently isolated from diseased canes of Co. 312 from Delhi State, gave maximum infection on three cane varieties, namely, Co. 213, 312, and 313, out of the ten under test.

In the varietal resistance tests, 190 important and promising cane varieties were tested by plug method and 92 by Nodal Infection method. In the former test, 172 varieties reacted as moderately resistant and 18 as susceptible, while in the Nodal Infection trials, one variety (Co. 312) reacted as resistant and 2 as moderately resistant.

In the experiment to determine the effect of mixed inocula on Red Rot infection, six combinations of light and dark, light and light, and dark and dark type isolates were tried on the ten standard cane varieties. Six varieties out of the ten tested, gave greater infection when inoculated with a mixture of isolates No. 244 (light) and 334 (dark) than with either of the two isolates separately. It was further observed that 7 varieties showed greater infection with the above mixed-inoculum than with the combination of two light type isolates No. 244 and 359. Similarly, 8 varieties gave more infection when inoculated with a mixture of isolates No. 78 (dark) and 244 (light) as compared to the combination of two light type isolates No. 244 and 359. The combinations of dark type isolates (334 and 372; 78 and 334), however, proved less virulent than the combinations of dark and light or light and light type isolates. In one of the dark type combinations (isolates No. 78 and 334) there was slight increase in virulence as compared to the infection obtained with either of the two component isolates, whereas in the second dark type combination (isolates No. 334 and 372) there was a slight decrease in virulence than with one of the components (No. 372). It was also confirmed that the amount of inoculum did not affect the intensity of infection.

(b) *Smut* (*Ustilago scitaminea* Syd.).—In the varietal resistance tests, 95 cane varieties at Delhi and 98 at Karnal were tested for their resistance to smut. At Delhi, 5 varieties showed less than 5 per cent infection, 12 gave 5—15 per cent, 22 showed 15—30 per cent and the remaining 56 gave 30—90 per cent infection. The corresponding figures for the Karnal experiment were 16, 14, 26 and 42 per cent. Twenty-one cane varieties, namely, Co. 312, 419, 421, 679, 914, 1001, 1005, 1006, 1007, 1014, 1027, 1037, 1040, 1046, 1134, 1160, 1168, 1169 and 1170 as also B.O. 22 and Co. S. 515, which showed less than 5 per cent infection, may be considered as resistant. Of these, varieties Co. 1005, 1006, 1007 and 1027 had reacted as resistant in the last year's test also.

(c) *Rust* [*Puccinia kuehnii* (Krueger) Butler].—The technique for maintenance of the rust on cut leaves and potted plants of sugarcane was standardized. It was found that rust on sugarcane was morphologically similar to *Erianthus* rust, but differed from *Saccharum spontaneum* rust. Temperature of 25°C was found to be optimum for the germination of uredospores of the three rusts. It was also observed that uredospores of sugarcane rust remained viable upto 18 weeks at 10°C.

6. *Linseed* (*Linum usitatissimum* L.):

Rust [*Melampsora lini* (Pers.) Lev.].—A survey for the rust incidence was undertaken in the State of Punjab in February—March, 1958, and moderate to heavy infection was observed in Kangra district. Eighty-three rust samples, collected from different parts of the country from 1956-57 and 1957-58 crops, were analysed and all the five races of *Melampsora lini*, so far reported from India, were encountered. In the

seedling resistance tests, linseed varieties E.C. 6158 and E.C. 6160 were found to be semi-resistant to all the five races, while E.C. 6163 was immune. Seventy-seven varieties or cultures were also tested in the adult stage, of which 66 proved resistant.

7. *Pigeonpea (Cajanus cajan* (L.) Millsp.):

Wilt (*Fusarium udum* Butler).—Twenty pigeonpea varieties were tested for their resistance to the disease. Three varieties (N.P. 41, S. 33-2 and S. 37-1) did not develop wilt symptoms, while six (N.P. WR (15), S-26-1, S. 57-1, S. 76-1, S. 77-2 and S 86-1) showed infection upto 3·5 per cent and may, therefore, be considered as fairly resistant.

8. *Antibiosis*:

Work on "Bulbiformin", the antibiotic produced by *Bacillus subtilis*, was continued. The antibiotic production in molasses or mustard cake supplemented soil was nearly five times more than in dextrose supplemented soil and it was further enhanced when both were added together. The higher production was found to be due to the combined action of certain vitamins, amino acids and carbohydrates. It was also observed that about 50 per cent of the antibiotic was adsorbed by sandy loam soil and 70 per cent by clay soil.

Good control of pigeonpea wilt was recorded in pot experiments by inoculating sterilized soil with *B. subtilis* or by seed bacterisation. The antibiotic was found to act systemically in pigeonpea plants when applied through roots.

9. *Physiology of Fungi*:

Further studies on the factors affecting the virulence of light (No. 244) and dark (No. 78) strains of *Colletotrichum falcatum* Went, the causal organism of Red Rot of Sugarcane, showed that the use of nitrogen sources, *e.g.*, asparagin, potassium nitrate, ammonium nitrate, pectin, casein, peptone and ammonium chloride alongwith the inoculum (conidial suspension) of the dark strain increased the linear spread of Red Rot infection in certain sugarcane varieties. Amongst the nitrogen sources, potassium nitrate was found to be the best. Furthermore, addition of sugarcane juice to the inoculum of the dark strain resulted in low infection, but when asparagin was added there was no reduction in infection. It was indicated that this reduction in infection was inversely proportional to the concentration of sugarcane juice used. The spore germination of the dark type was also found to be inversely proportional to the concentration of sugarcane juice tried. Finally, addition of culture filtrate of the light or dark type isolate to the cane variety Co. 647 alongwith the inoculum of the dark type isolate increased linear spread of infection.

Conditions influencing the production of perfect stage of *C. falcatum* were also studied. Perithecia were readily formed on dried autoclaved sugarcane leaves when incubated in contact with water at 25°C. The presence or absence of light, however, seemed to have no effect. No perithecia developed on green or partially green leaves or on the rind of cane. Besides sugarcane leaves, the perithecia could be produced on *Erianthus munja, jowar* and bamboo.

Further work on the nutritional requirements of *Lophotrichus ampulus* Benj. showed that a medium consisting of lactose, glutamic acid, magnesium sulphate, calcium chloride, trace elements, thiamine and biotin, adjusted at neutral pH, supported very good growth and sporulation of the fungus when the cultures were incubated at 28°—30°C.

Safflower callus tissue was maintained and carried through 8 generations on White's solid medium containing 0·1 p.p.m. of naphthalene acetic acid which had been found to be essential for the development of normal undifferentiated tissue. Callus growth of sannhemp tissue from healthy stem tips was also successfully grown on White's medium.

10. *Effect of atomic radiations on micro-organisms*:

Studies on the mutagenic and stimulative effects of ionizing radiations, from different sources, on *C. falcatum* were continued. Using varying levels of activity of P^{32} in dextrose-asparagin-phosphate medium, isolate No. 244 of the pathogen was irradiated in the growth phase and number of mutants, showing variation in cultural and morphological characters as also in biochemical reactions, were picked up.

Further studies on the colour mutant, induced through the bombardment of Fast neutrons, confirmed the earlier findings that the variation was neither controlled by nutritional requirement nor by enzymatic reaction. The spore germination of the mutant was less as compared to that of the parent culture on various substrata tried.

Work on the biochemical mutant, obtained with the aid of 240 microcuries/ml. of P^{32}, showed that none of the nitrogen sources, trace elements and desoxyribonucleic acid had any effect on the deficiency of the mutant. Vitamin studies, however, indicated that an acute deficiency of p-aminobenzoic acid had been induced. Growth and sporulation of the mutant obtained in the presence of this vitamin were almost similar to those of the culture. It was also shown that the parent culture synthesized its own requirement of p-aminobenzoic acid which could be inactivated by the addition of sulphanilamide. Some more biochemical mutants were screened out with the aid of P^{32} (100 and 300 microcuries/ml.) and these gave indications of deficiencies in biotin, nicotinic acid and some amino acid.

Stimulative effects on the germination of spores of *C. falcatum* (isolate No. 244) were observed when the spores were irradiated with 30 roentgens of gamma rays obtained from radon gas and with 12,000 roentgens of X-rays obtained from 220 KV and 15 mA machine. The growth of *Xanthomonas vesicatoria*, the causal organism of leaf spot of chilli, was suppressed during the first 5 days when the inoculum was treated with P^{32} for 48 hours at 7°C.

11. *Fungicides*:

Nitrated trichlorobenzene and Zerumbone as also alcohol and benzene extracts of *Lawsonia alba*, prepared by the Organic Chemist, were screened for fungitoxicity in the laboratory, but none of them showed any fungicidal properties.

A laboratory experiment was conducted to test the comparative efficacy of 22 proprietary fungicides, namely, Copper carbonate, Cuprous oxide, New Improved Ceresan (ethylmercury phosphate), Ceresan M[(N —(ethylmercury)—p—toluenesulphonanilide)], Cerenox (organically combined mercury), Arasan (tetramethylthiuram disulphide), Fusariol (ethylmercury cyanide), Thiram and Fernasan [bis (dimethyl thiocarbamoyl) disulphide], Leytosol (Phenylmercuriurea), Spergon (tetrachloro-p-benzoquinone), Semesan (2-chloro-4-(hydroxymercuri) phenol], Tillex (ethylmercury chloride), Phygon (2, 3-dichloro-1, 4-naphthoquinone), Tritisan (pentachloronitrobenzene), Agrosan GN (tolymercury acetate), Agrosan 5W (organically combined mercury), Flit 406 [n-(trichloro-methylmercapto)-4-cyclohexene-1, 2—dicarboximide], Puraseed (N-phenylmercuriformamide; antimonocadmium lactate), Zerlate (zinc dimethyldithiocarbamate), Parzate dry (zinc ethylenebisdithiocarbamate) and Phenylmercury acetate, for the control of "damping off" of chillies (*Pythium de Baryanum*). It was recorded that pre-and post-emergence "damping off" was reduced to 6·6 per cent and 6·3 per cent, respectively, when seeds were treated with Flit 406 as against 40·8 and 78·2 per cent in untreated controls.

In a comparative field fungicidal trial against Hill bunt of wheat (*Tilletia foetida*) at Simla, Fusariol, Agrosan GN, Hexasan (organic mercury compound), New Improved Ceresan, Lunasan [1-(ethylmercuri)-2-thiourea], Tritisan, Tillex, Harvesan and Flit 406 were tried as seed protectants. Wheat seed treated with Flit 406 and New Improved Ceresan showed 74 per cent and 64·5 per cent germination, respectively, as compared to 51 per cent in the control. The disease incidence ranged from 1·1 to 1·6 per cent in the crop raised from seed treated with New Improved Ceresan, Fusariol, Agrosan GN and Tritisan as against 76·2 per cent in the control. Of the nine fungicides, *i.e.*, Ultra sulphur, Sulphur, Dithane Z-78 (zinc ethylenebisdithiocarbamate), Parzate liquid (disodium ethylenebisdithiocarbamate) plus zinc sulphate, Dithane M-22 (manganese ethylenebisdithiocarbamate), Fernate (ferric dimethyldithiocarbamate), Ziram (zinc dimethyldithiocarbamate), Flit 406 and Merbam (Phenylmercury dimethyldithiocarbamate) tried for the control of black rust of wheat, 3 sprayings of Parzate liquid (disodium ethylenebisdithiocarbamate) plus zinc sulphate, given at an interval of 15 days from 15th February, reduced severity of the rust and increased yield by 28 per cent.

In a comparative seed dressing fungicidal trial for the control of stripe disease of barley (*Helminthosporium gramineum*) all the 9 fungicides (New Improved Ceresan, Ceresan, Lunasan, Fusariol, Harvesan, Tillex, Agrosan GN, Agrosan 5W and Flit 406) showed beneficial effect in reducing infection and increasing germination. In another experiment for the control of covered smut of barley (*Ustilago hordei*) with 19 fungicides (Arasan, New Improved Ceresan, 2% Ceresan, Cerenox, Harvesan, Spergon, Tillex, Thiram, Lunasan, Phygon, Fusariol, Ceresan M, Agrosan GN, Fernasan, Flit 406, Hexasan, Leytosol, Tritisan and Agrosan 5W), Ceresan M and Agrosan 5W reduced infection to 0·1 per cent and 0 per cent, respectively, as against 10·6 per cent in the control.

In the field experiment against stem rot of jute (*Macrophomina phaseoli*) with 9 fungicides (Agrosan 5W, Fusariol, Agrosan GN, Hexasan, Flit 406, New Improved Ceresan, Fernasan, Harvesan and

Thiram), seed treatment with Agrosan 5W reduced infection from 45·3 per cent to 7·0 per cent. Furthermore (3 sprayings of Fytolan and Cuprous oxide (Kirti) reduced the incidence of fruit rot of chilli (*Colletotrichum capsici*) to 7·9 per cent and 9·2 per cent, respectively as against 25·5 per cent in the control.

About 18 per cent increase in yield from the sugarcane plots planted with setts treated with Aretan at the rate of 1 lb. in 10 gal. of water ('In and out dip') was obtained as compared to the untreated control.

12. *Seed Testing*:

Forty-three seed samples of wheat, obtained through the Regional Directors of Food, were examined for ecto-and endo-phytic fungal flora. All of them were found to be free from any internally or externally borne pathogenic fungi, although some of them were externally infected with some saprophytic fungi, e.g., *Mucor, Rhizopus, Penicillium, Alternaria, Aspergillus* and *Curvularia*, either singly or in different combinations.

Twenty samples of vegetable seeds, collected from Delhi and other markets, were also examined for externally as well as internally carried pathogens. The seed samples of radish, French bean and chilli yielded *Alternaria* sp., *Colletotrichum lindemuthianum* and *Colletotrichum capsici*, respectively. In addition, a survey of seed-borne fungal pathogens of 20 *kharif* and *rabi* vegetables was made and 27 potentially pathogenic fungi, which included species of *Fusarium, Ascochyta, Alternaria, Rhizoctonia, Helminthosporium, Phomopsis, Aspergillus, Colletotrichum* and *Sclerotium*, were isolated.

About 637 seed samples, intended for export to foreign countries, and 788 samples, received from abroad, were examined for ecto-and endophytic fungal flora and suitably treated with fungicides.

13. *Assessment of losses*:

Experiments were set up to assess losses caused by groundnut mosaic, Angular leaf spot of cotton (*Xanthomonas malvacearum*), late blight of potato (*Phytophthora infestans*), linseed rust (*Melampsora lini*) and powdery mildew of pea (*Erysiphe polygoni*).

Score card on the basis of twig reduction was formulated to assess losses due to groundnut mosaic. At I.A.R.I. farm, natural infection, varying from 0 to 100 per cent, was catagorised into five classes with corresponding losses in yield ranging from 0 to 88 per cent. In the case of late blight of potato, loss in yield upto 30 per cent was recorded when the disease appeared one month before harvest. About 23 per cent loss in pod yield was observed due to powdery mildew of pea under natural conditions of infection at Simla. The results obtained in connection with linseed rust showed that time or stage of infection of the plant and intensity of infaction were important factors in assessing losses due to this disease. For determining losses in susceptible varieties, twig infection alone could serve a useful index, but for resistant varieties both twig and leaf infection had to be taken into consideration. Lastly, infection on leaves, stems and pods was found to be positively correlated in the case of susceptible varieties, but not with resistant varieties. No observations could, however, be taken in the case of angular leaf spot of cotton as the artificially inoculated crop failed.

4. *Miscellaneous*:

(a) *Cultivation of edible mushrooms under Delhi conditions.*—Studies on the cultivation of paddy straw mushrooms (*Volvaria diplasia* and *V. volvacea*) were continued. The yield of *V. volvacea*, the Indonesian mushroom, was comparatively more than that of *V. diplasia* under identical conditions. Attempts to cultivate the European mushroom (*Psalliota campestris*) with Darlington Dry 100 per cent spawn of white variety in beds composted with horse dung, however, failed, although temperature and other conditions were quite favourable for the growth of mushrooms.

(b) *Nematodes in relation to plant diseases.*—A survey for plant parasitic nematodes in different parts of the country was continued. Root-knot disease was observed in chilli, *Lycopersicon pimpinellifolium* and *Carum copticum*. Root-knot of *Carum copticum* appears to be the first world record. *Meloidogyne* sp. (Root-knot nematode) was also found associated with a small number of diseased cumin plants, but the population of this nematode as also of *Helichotylenchus* and *Hoplolaimus* in the soil samples, collected from the diseased area, was very small and, therefore, it appeared doubtful whether any of these nemas could be the cause of the disease which was so widespread. Soil samples from rice fields of Madhya Pradesh showed the presence of a small population of *Radopholus* sp., while those collected from sugarcane fields of Madras yielded high numbers of *Helichotylenchus* and *Rotylenchus*. Citrus roots, suspected to be affected with "Spreading decline" in Coorg, showed the presence of *pratylenchus*. Plant prasitic nematodes were also found to be associated with cotton, carrot, papaya and *Solanum nigrum*.

(c) *Blight disease of brinjal* [*Phomopsis vexans* (Sacc. and Syd.) Harter].—This disease appeared in a severe form in the Botany and Horticulture Divisions of I.A.R.I. In preliminary studies, it was found that temperature had considerable effect on the growth and sporulation of the pathogen. Optimum growth was obtained at 17°-30°C., while sporulation was best at 20°-25°C. This is in variance with the results obtained by workers abroad, who have reported the optimum temperature for sporulation as 27°C. Seed appeared to be the primary source of infection.

(d) *Grain smut of jowar* [*Sphacelotheca sorghi* (Link) Clint.].—In the varietal resistance tests with 21 *jowar* varieties, 16 proved susceptible. As the general incidence of the disease was low, the varieties that did not show infection would require to be retested.

B. *Section of Plant Bacteriology*

15. "*Tundu*" (*Yellow-ear rot*) *disease of wheat* (*Corynebacterium tritici* (Hutchinson) Bergey *et al.*): In order to determine the relationship between the bacterium (*C. tritici*) and the nematode (*Anguina tritici*), a large number of isolations were made from the nematode galls on a selective medium for the genus *Corynebacterium*. Several bacteria, including some yellow Gram positive ones, were obtained, and are under study. Preliminary attempts were also made to free nematodes from contaminating bacteria by the use of antibiotics, but so far negative results have been obtained.

16. *Citrus Canker Xanthomonas citri* (Hasse Dowson): Last year's studies had shown that the pathogen could not survive in soil for more than 17 days, while in the infected leaves it remained viable for sufficiently long periods so that the diseased leaves could serve as a primary source of infection. This rapid decline of the pathogen in soil has been attributed either to the antagonistic effect of other soil microflora or to the presence of bacteriophage in soil. Seventy-five bacteria, 54 actinomycetes and one bacteriophage were isolated from soil in this connection. None of the bacteria was found antagonistic to the pathogen, whereas 7 actinomycetes showed varying degrees of antagonism. Effect of the bacteriophage on the survival of the pathogen in soil is, however, being studied.

17. *Bacterial leaf spot of chilli Xanthomonas vesicatoria* (Doidge Dowson): Host-range studies and varietal resistance tests were in progress. Fifty-four chilli varieties were tested for their resistance to the disease, of which 5 varieties (Kondeveram, Patna, Suryamukhi Red Erect, Bombay 469 and N.P. 10) did not take infection in the three tests conducted. Furthermore, *Datura stramonium*, *Lycopersicon esculentum*, *L. pimpinellifolium*, *Solanum nodiflorum*, *S. nigrum*, *S. melongena*, *Nicotiana glutinosa* and *Spinacia oleracea* were found to be susceptible to the disease, whereas *Lactuca sativa* and *Nicotiana tabacum* vars. Harrison Special and white Burely did not take infection. Amongst the susceptible hosts, *S. nodiflorum*, *S. melongena* and *S. nigrum* appeared to be highly susceptible as these could be readily infected.

18. *Bacteriophages in relation to bacterial plant pathogens*: Bacteriophage for *Xanthomonas citri* (citrus canker), isolated from diseased leaves, was found to be host specific. A medium, consisting of glucose, ammonium sulphate, potassium chloride, magnesium sulphate and yeast extract, was found to be most suitable for both lysis and plaque formation. Temperature of 27°C. and pH 7·5 appeared to be optimum for this purpose. Attempts are now being made to isolate more phages for *X. citri* and for other species of *Xanthomonas* with a view to determine whether phage specificity can be used as a criterion for delimiting species within this genus.

19. *Use of antibiotics in the control of bacterial diseases of plants*: Preliminary experiments were set up to study *in vitro* the effect of Agrimycin-100 on different species of *Xanthomonas* reported from India. Of the 19 species tested so far, *X. punicae* and *X. malvacearum* were inhibited at 20 ugm/ml. concentration of the antibiotic, while *X. citri*, *X. vesicatoria*, *X. campestris*, *X. nigricola*, *X. betlicola*, *X. alfalfae*, *X. ricinicola*, *X. tamarindi*, *X. cassiae*, *X. trichodesmae*, *X. melhusii*, *X desmodii*, *X. uppalii*, *X. badrii*, *X. sesbaniae*, *X. clerodendron* and *X. poinsettiacola* were not affected.

C. *Section of Plant Viruses*

20. *Bhindi* (*Abelmoschus esculentus* Moench:

Yellow-vein mosaic.—In the varietal resistance tests, *Abelmoschus manihot* (*Portuaese*) and *A. crinitus* were found to be immune. A weed (*Triumfetta rhomboidea*), showing yellow-vein mosaic symptoms under natural conditions, did not prove to be an alternative host of the virus when indexed on *bhindi*. In host-range studies, a large number of cucurbit and other crop plants were artificially inoculated through the viruliferous white-flies, but none of them was infected.

21. *Chilli* (*Capsicum frutescens* L.):

Mosaic and leaf curl.—Varietal resistance tests against the two diseases were in progress. Varieties Puri Red, Puri Orange, Cuttack Red Erect, Kondeveram and R. S. 8 as also a cross between Puri Red and N.P. 46A proved to be resistant to chilli mosaic virus. Chilli variety Bombay 569 and *Solanum nodiflorum* were found to act as symptomless carriers for the same virus.

22. *Brinjal* (*Solanum melongena* L.):

(a) *Mosaic.*—A large number of collections of mosaic affected *brinjal* plants were analysed for the presence of viruses involved and four different viruses were isolated. One of these was a strain of tabacco mosaic virus; another was suspected to be a strain of cucumber mosaic virus; and the remaining two appear to be new records on *brinjal.*

(b) *"Little-leaf" disease.*—All the six *brinjal* varieties, *viz.*, Long Purple I. C. 139, Long Purple I. C. 1417, Round Purple, Mysore Green Long, Blava Beauty and Chinese Green Long, which were tested for their reaction to the virus, proved to be susceptible.

23. *Sesamum* (*Sesamum indicum* DC.):

Phyllody.—The virus was successfully transmitted to *Trifolium alexandrinum, T. lappaceum, Medicago scutellata, Melilotus indica, Phlox drummondii* and *Petunia violacea* through viruliferous jassids (*Deltocephalus* sp.). In the varietal resistance tests, all the 12 varieties of sesamum (N.P. 3, N.P. 6, N.P. 7, N.P. 12, N.P. 16, N.P. 18, N.P. 29, I.C. 2535, E. C. 2538, E.C. 4824, EC. 4828 and EC. 4898) and *Seasamum prostratum* tested by grafting or through viruliferous jassids were found to be susceptible. Disease incidence in the sesamum crop, grown in the Institute area during the year under report, was found to be 8-10 per cent.

24. *Cotton* (*Gossypium* spp.):

"Small-leaf" disease.—All the five different species of *Gossypium*, viz., *G. barbadense, G. raimondii, G. anomalam, G. stocksii and G. davidsonii*, tested for their resistance to the disease, proved to be immune. In host-range studies, the virus could not be transmitted to *Thespesia populnea.*

25. *Sugarcane* (*Saccharum officinarum* L.):

(a) *Mosaic.*—A severe type of mosaic, observed in the sugarcane variety Co. 527, was being studied with a view to identify the strain involved. All attempts so far made to transmit the virus by mechnical means to maize, *jowar* and certain sugarcane varieties (Surkha Saharanpuri, Co. 213 and Co. 313) have failed. It appears that the virus loses its viability readily in extracted juice and, therefore, the conditions under which it would be possible to secure infection are being studied.

(b) *"Grassy-shoot" disease.*—In host-range studies, the virus was transmitted to Napier grass (*Pennisetum purpureum*) and *Phaseolus vulgaris* both by mechanical inoculation and through the vector, *Longiunguis sacchari, L. pseudosacchari* and *Aphis maidis* were found to be additional vectors of the virus. The virus was found to withstand dilution of 1 in 10 000. In the varietal resistance tests, all the eight varieties of sugarcane (Co. 787, Co. 791, Co. 845, Co. 908, Co. 915, Co. 922, I. C. V. 231 and I. C. V. 235) tested proved to be susceptible.

26. *Sannhemp* (*Crotalaria juncea* L.):

Mosaic.—The virus was found to multiply and undergo an incubation period of 3-4 days at the site of inoculation before moving to the uninoculated regions of leaves when temperature in the glasshouse varied between 24° to 44°C. The virus was generally found to move in both upward and downward directions simultaneously; but, sometimes, on reaching the stem, it first moved downward and then upward and was located in the roots after 9 days of inoculation. The incubation period was observed to be influenced by air temperature, being longer at low temperatures. Sannhemp plants could be infected by root inoculation by the pinprick method and the virus moved in upward direction, producing symptoms in the aerial parts in about 8-10 days after inoculation.

27. *Chinese sarson* (*Brassica juncea* Czern. and Coss. var. *rugosa* Roxb.):

Mosaic.—In host-range studies, the virus was transmitted to Chinese cabbage variety Pe Tsai, but not to *Mesembryanthemum* sp.

28. *Broadbean* (*Vicia faba* L.):

Mosaic.—The causal virus was identified as a strain of *Pisum* virus 2 and was found to be seed-borne. It was transmitted to *Pisum sativum* var. Laxton's Progress, *Medicago lispida*, *Trifolium pratense* and *Lupinus texanum*, but not to *Nicotiana tabacum* var. White Burley, *Datura stramonium*, *Gomphrena globasa* and *Mesembryanthemum* sp. The thermal-death point of the virus was found to lie between 52°C to 55°C and its presence in the roots of diseased broadbean plants was experimentally established.

29. *Lettuce* (*Lactuca sativa* L.):

Mosaic.—The virus was readily transmitted with the sap extracted in 0:5 per cent solium sulphitic solution and through the seeds obtained from mosaic affected plants. *Myzus persicae* was found to be an additional vector of the virus. Thermal-death-point of the virus lies between 50°C and 55°C and dilution-end-point between 1:50 and 1:100. Attempts are now being made to produce indexed disease-free seed of lettuce.

30. *Cardamom* (*Amomum subulatum* Roxb):

(a) *"Foorkey" disease.*—The disease was transmitted to four varieties of large cardamom (*Amomum subulatum*), two wild species of *Amomum* and small cardamon (*Elettaria cardamomum*), but not to *Curcume longa* and *Zea mays*.

(b) *"Chirke" disease.*—The disease, which is characterised by mosaic symptoms on leaves, was successfully transmitted by mechanical means, proving its virs nature. In host-range studies, the virus was transmitted to Arrow root and wheat. Cardamom varieties Ramnok, Ramosa and Sawney, tested for their resistance to the disease, proved to be susceptible, studies on physical properties of the virus and to determine the vector are in progress.

31. *Papaya* (*Carica papya* L.):

(a) *Mosaic.*—Search for alternative hosts of the virus were continued. Plants of *Petunia hybrida, Cucumis sativus, Datura inoxia, Duranta repens, Althaea rosea, Brassica oleracea* var. *capitata* and banana, showing mosaic symptoms, were indexed on papaya seedlings, but none proved to be an alternative host. In the varietal resistance tests, all the 16 varieties so far tested have been found to be susceptible.

(b) *Leaf curl.*—Experiments on the relationship between age of the host and infection were in progress. Papaya plants inoculated when 8-9 months old produced disease symptoms after 8-9 months, whereas those inoculated when 2-4 months old exhibited disease symptoms within 2-4 weeks. The papaya plants infected when young and kept in glasshouse under high temperatures recovered from the disease, but recovery appeared to be temporary as these plants developed disease symptoms later when transplanted in the field.

32. *Banana* (*Musa sapientum* L.):

Mosaic (or *Chlorosis*).—The virus was successfully transmitted by juice inoculation as well as through viruliferous aphids (*Aphis gossypii*) to *Cucumis sativus*, but could not be transmitted back to banana from diseased cucumber plants. *Aphis malvae* could not transmit the virus. In the varietal resistance tests, varieties China Botha, Hajari and *Musa balbisiana* did not take infection when inoculated through *Aphis gossypii*.

33. *Gooseberry* (*Physalis peruviana* L.):

Mosaic.—The virus was identified as a strain of tobacco mosaic virus. In host-range studies, the disease was transmitted to *Nicotiana sylvestris* and *N. tabacum* var. *Xanthi-nc*, but not to *Crotalaria juncea* and *Abelmoschus esculentus*. The virus was found to be infectious even after storage for more than 2 years at room temperature under Poona conditions. Attempts to transmit the virus with an unidentified species of grasshopper were not successful. The virus was readily transmitted by hands contaminated with chewing tobacco, but not through seed or soil.

34. *Mango* (*Mangifera indica* L.):

Malformation.—Transmission tests by grafting as well as through insects were continued. The disease was successfully transmitted by wedge grafting. The systemic nature of the disease was proved as it was found to reappear in plants which were regularly sprayed with 'Ekatox' after removal of the diseased portions. 'Bunchy top' symptoms were produced on mango stocks, wedge-grafted with shoots from malformed inflorescence, establishing thereby that the two types of symptoms produced in nature are caused by the same virus. The disease could not be transmitted through soil or mechanical injury of roots or growing shoots. Experiments to determine the insect vector were taken up.

35. *Citrus* (*Citrus* spp.):

"Decline" disease.—Citrus plantations in Bombay, Coorg, Punjab, U.P. and Bengal were surveyed and "decline" symptoms were observed in different species of *Citrus*. The virus was successfully transmitted by grafting from Kagzi lime to Key lime and *Aeglopsis chevalieri*, developing

symptoms similar to those produced by "Tristeza" virus. *Toxoptera citricidus* was established to be the vector of the virus and the disease was successfully transmitted from diseased Kagzi lime, citron, grape fruit and *mosambi* to West Indian Key lime and *Aeglopsis chevalieri* through the vector.

36. *Temperate fruits*:

Yellow mosaic of Red Gold apple and mosaic of Golden Delicious apple were established to be of virus origin. The line-pattern of plum was transmitted to plum varieties Formusa and Green, and plum mosaic to Green Cage, Beeky Smith, Green and Satsuma plum. Mosaic of *Rubus ellipticus* was tranmitted by means of dodder (*Cuscuta reflexa*).

37. *Development of new strains, serological relationship and cross-immunity studies*:

The seven virus cultures, isolated as a result of spontaneous mutation in potato virus X, continued to show differences in pathogenicity when tested on additional differentials, *viz.*, *Nicotiana glutinosa, Cyphomandra betacea* and *Petunia hybrida-compacta* vars. Rosy Morn, Brilliant Rose, Deep Red and Pendula Blue.

In cross-protection tests, carried out in tobacco plants with Tobacco mosaic and *Dolichos* enation mosaic viruses, it was observed that either age of tobacco leaves or some unknown factor prevented multiplication of *Dolichos* enation mosaic virus in them. Partial injury to leaves caused by rubbing did not affect multiplication of *Dolichos* enation mosaic virus in tobacco leaves.

Gooseberry mosaic virus was shown to be a strain of tobacco mosaic virus by cross-protection tests carried out in *Nicotiana sylvestris*. Likewise, it was found that the S-isolate of *brinjal* mosaic virus was not related to either the L-isolate of *brinjal* mosaic virus or tobacco mosaic virus.

38. *Isolation and purification of plant viruses and study of their properties*:

Attempts were made to purify papaya mosaic virus, but the virus being very unstable did not withstand various treatments and lost infectivity. Studies relating to the purification of bottlegourd mosaic virus were taken up.

39. *Virus-vector relationship*:

Even a single alate female of the banana aphid, *Pentalonia nigronervosa*, could transmit the "Foorkey" disease of large cardamom. Similarly, single viruliferous aphid (*Longiunguis sacchari*) was able to transmit the "grassy shoot" disease, but the optimum infection was obtained with groups of 10 aphids. The aphids were able to acquire the virus from diseased plants in 5 minutes and transmit it to healthy cane plants in 10 minutes. The acquisition, inoculation and transmission threshold values of mosaic virus of *Chinese sarson* with respect to its vector, *Brevicoryne brassicae*, were found to be 15, 10 and 60 seconds, respectively. The aphid lost the virus, which was typically of non-persistent type, between 1½ to 2 hours.

40. *Control*:

Experiments on the direct control of the vector, *Bemisia tabaci*, by spraying with different insecticides with a view to check the spread of tomato and sesamum leaf curl diseases were repeated. Spraying with Folidol E 605' and 'Ekatox 20' was found to reduce incidence of the two diseases, resulting in appreciable increase in yield as compared to the controls.

Attempts to cure "grassy shoot" disease of sugarcane by heat therapy were continued.

41. *General*:

Dolichos enation mosaic virus was transmitted to *Nicotiana tabacum*, *N. tabacum* var. *Xanthi-nc*, *Datura tatula*, *D. chlorantha*, *D. aegyptiaca* and *Physalis floridana*, but not to *Abutilon indicum*. "Chirke" disease or ginger was transmitted through diseased rhizomes. Tobacco distortion mosaic virus was transmitted to *Physalis ixocarpa*, *P. minima*, *P. floridana*, *Hyoscyamus niger* and *Nicotiana sylvestris*, while mosaic of *Datura metee* was transmitted to *Hyoscyamus niger*, *Petunia hybrida compacta* and *Cyphomandra betacea* (tree tomato). Attempts to determine the vectors of groundnut mosaic, tomato necrosis and sterility disease of pigeonpea were in progress.

D. *Section of Systematic Mycology*

42. *Taxonomy*:

Critical studies of the genus *Alternaria* were continued. *Alternaria tenuis* group, which includes a large number of variable forms, was studied and it was felt that the morphological characters alone did not offer any solution to the problem of taxonomy of this group. *Alternaria palandii* Ayyangar on *Allium cepa* and *A. citri* Pierce on *Citrus* spp. appear to belong to this group. *A. cheiranthi* (Fr.) Bolle was recorded for the first time in the country.

Two species of *Cercospora*, namely, C. *osbeckiae* and *C. pycnicola* on *Osbeckia stellata* and *Capparis sepiaria*, respectively, were established as new species. Also, 19 *Cercospora* spp. were recorded for the first time in India, and these are: *C. amorphophalli* Henn. on *Amorphophallus* sp.; *C. buddleiae* Yamamota on *Buddleia* sp., *C.* cavarae Sacc. on *Glycyrrhiza glabra; C. cotizensis* Mueller and Chupp and *C. crotalariae* Sacc. on *Crotalaria* spp.; *C. cruciferarum* Ell.. and Ev. on *Raphanus sativus; C. davisii* Ell. and Ev. on *Melilotus parviflora; C. euphorbiaecola* Atkinson on *Euphorbia* sp.; *C. jujubae* Chowdhuri on *Zizyphus jujuba; C. malayensis* Stev. and Solheim on *Hibiscus sabdariffa; C. mississippiensis* Tracy and Earle on *Smilax* sp.; *C. pallidissima* Chupp on *Smilax aspera; C. petuniae* Mueller and Chupp on *Petunia* sp.; *C. psoraleae* Ray on *Cyamopsis tetragonoloba; C. riachueli* Speg. on *Vitis trifolia; C. rubrotincta* Ell. and Ev. on *Prunus amygdalus; C. ubi* Racib. on *Dioscorea sativa; C. Voandzeiae* Bouriquet on *Voandzeia subterranea*; and *C. zebrina* Pass. on *Trifolium alexandrinum.*

Studies on the genus *Colletotrichum* were also undertaken. Amongst the new host records for the genus were *Montbretia* sp.; *Chenopodium album, Pisum sativum* and *Cinnamomum* sp. In Hyphomycetes, 2 species of *Corynespora, Myrothecium* sp. on *Urochloa* sp., *Pyrenochaeta* sp. on *Phalaris minor, Helminthosporium turcicum* Pass. on *Sorghum vulgare* and *Stemphylium* sp. on *Tecoma* sp. were found to be interesting. Two genera of Hyphomycetes, namely, *Goniosporium* Link and *Diploplenodomus* Died., new to India, were also studied.

A large number of powdery mildews were collected from Kulu Valley. These included the following new records for India: *Uncinula clandestina* (Biv. Bern) Schroet. on *Ulmus* sp.; *U. salicis* (DC.) Wint. on *Populus* sp.; *Microsphaera alni* (Wallr.) Salm. on *Juglans regia; Phyllactinia corylea* (Pers.) Karst. on *Ulmus* sp. and *Salix* sp.; *Sphaerotheca fuligenea* (Schlecht.) Pollacci on *Cosmos* sp.; and *Erysiphe umbelliferarum* de Bary on *Daucus carota.*

Studies on Miscellaneous Indian Fungi were continued. A large number of fungi of interest, including 8 new species and 30 new records for India, were studied. Amongst the parasitic fungi, a new species of *Puccinia* on *Gladiolus* sp.; *Microdiplodia* sp. on apple; and *Polystigma rubrum* (Fr.) DC. on almond deserve special mention.

43. *Herbarium:*

Five hundred and thirty-seven mycological specimens (both Indian and Foreign) were added to the Herbarium during the year under report, bringing the total number of accessions to 25,945. One hundred and twelve specimens of fungi, including several types, were supplied to various Indian and Foreign workers. A large number of mycological specimens collected locally and received from different sources were identified. An Exsiccati set on "Indian Erysiphales" was under preparation. World literature on the taxonomy of fungi and a list of specimens available in the Herbarium were being compiled.

44. *Indian Type Culture Collection:*

During the period under report, 17 fungal and bacterial cultures were added to the Collection, bringing the total number of cultures to 1,100. In addition, 54 cultures of 13 different rusts of various crops and 46 cultures of various plant viruses are being maintained. About 172 cultures were supplied to various scientific workers and research institutions in the country and abroad. A consolidated list of the cultures maintained in the Collection has been revised and brought up-to-date. Studies on mineral oil and soil preservation of fungi were continued.

45. *Commonwealth Phytopathological News:*

Scientific information on latest researches of nterest carried out in India were communicated to the Commonwealth Mycological Institute U.K., and these were published by them in the form of four notes.

PROGRAMME OF WORK FOR 1958-59

(a) *Plant Pathological Investigations*:

(i) Studies on cereal smuts and bunts.

(ii) Determination of physiologic races of *Puccinia graminis tritles, P. triticina, P. glumarum, P. sorghi, P. hordei, Melampsora lini, Ustilago tritici, Tilletia foetida, T. caries, Neovossia indica* and *Colletotrichum falcatum.*

(iii) Studies on rusts of wheat, barley, oats, maize, sannhemp, linseed, sugarcane and wild grasses.

(iv) Green-ear disease of *bajra;* "Molya" disease of barley.

(v) Assessment of damage due to certain crop diseases.

(vi) Efficacy of different seed-dressing fungicides; laboratory, pot culture and field testing of proprietary fungicides and new compounds; chemotherapy; study of ecto- and endo-phytic fungal flora of stored seeds.

(vii) Testing varieties of crop plants for their resistance to diseases, with particular reference to wheat and barley rusts and smuts, bunts of wheat, linseed rust, pigeonpea wilt and grain smut of *jowar.*

(viii) *Diseases of sugarcane*: Factors affecting variation in *Colletorichum falcatum* and recurrence of Red-rot epidemics; role of the perfect stage of *C. falcatum* in the origin of new virulent strains; virulence of mixed inocula of *C. falcatum* isolates. Evolving of cane varieties resistant to red-rot and smut and studies on the inheritance of their resistance.

(ix) Studies on microbial antagonism and antibiotics; plant tissue culture; physiology of fungi; physiology of parasitism of some less specialised plant pathogens; study of factors affecting virulence of light and dark type isolates of *C. falcatum.*

(x) *Bacterial diseases of plants*: Yellow ear-rot of wheat; red-stripe of sugarcane; stalk rot of maize; bacteriophages in relation to bacterial plant pathogens; nematode-micro-organism association; survey of bacterial diseases of fruits and vegetables.

(xi) *Radioactive Isotopes*: Effects of ionizing radiations on plant pathogenic microorganisms with particular reference to *Colletotrichum falcatum, Ustilago tritici,* bottlegourd mosaic virus and sannhemp mosaic virus; study of the phenomenon of wilting in pigeonpea plants, caused by *Fusarium udum* Butler; radiation therapy.

(b) *Plant Virus Investigations:*

(i) Studies on mosaic diseases of *brinjal,* chilli, sugarcane, groundnut, banana, plum, *Rubus ellipticus* and *Vicia faba;* yellow-vein mosaic of *bhindi; Dolichos* enation mosaic; sterility

disease of pigeonpea; phyllody of sesamum and other oilseed crops as also of *Brassica* spp; "Smalling" disease and necrosis of tomato; leafcurl of chilli; "Foorkey" and "Chirke" diseases of large cardamom; "Grassy-shoot" disease of sugarcane; "Small-leaf" disease of cotton; mango malformation; "Line-pattern" disease of plum; and virus diseases of citrus.

(ii) Fundamental studies on virus-vector relationship of sesamum phyllody, banana mosaic, "Foorkey" disease of large cardamom and "Grassy-shoot" disease of sugarcane. Purification of Southern sannhemp mosaic, *Crotalaria mosaic* (Delhi strain), *Dolichos* enation mosaic, bottlegourd mosaic and *brinjal* mosaic viruses and study of their properties; inactivation of plant viruses; development of new strains.

(iii) Control of tomato leaf curl, leaf curl and phyllody of sesamum, papaya mosaic and "Grassy-shoot" disease of sugarcane; testing varieties of crops for their resistance to diseases, *e.g.*, "Yellow-vein" mosaic of *bhindi*, "Small-leaf" disease of cotton, sesamum phyllody, chilli mosaic, and banana mosaic.

(iv) Survey of plant virus diseases.

(c) *Mycological Investigations*:

(i) Taxonomic study of new and unidentified collections available in the *Herb. Crypt. Ind. Orient.*; preparation of exsiccati sets of Indian Fungi, list of fungi deposited in the Herbarium and card-indices of species of fungi represented in India; collection of world literature on the taxonomy of fungi. Study of fungal flora of Delhi; identification of fungi and disease specimens; taxonomic studies of Hyphomycetes, Meliolales, Erysiphales, *Alternaria*, *Cercospora* and *Nectria;* and maintenance of host index of fungi.

(ii) Maintenance of Indian Type Culture Collection of microorganisms and their history sheets; study of methods for preservation of fungi and bacteria.

(d) *Miscellaneous*:

Routine and advisory; post-graduate teaching and training of plant-protection and short-course students; assistance and advice to Indian Council of Agricultural Research, Indian Central Cotton Committee, Indian Central Sugarcane Committee. Indian Central Oilseeds Committee, *etc.*; co-ordination or mycological and plant pathological research.

REPORT OF THE DIVISION OF SOIL SCIENCE & AGRICULTURAL CHEMISTRY

(DR. R. V. TAMHANE)

A. Agricultural Chemistry

(a) *Soil Fertility*

1. *Comparative efficiency of various nitrogenous fertilizers.*—In view of the project of manufacturing new fertilizers in the country, a few of those fertilizers imported from abroad were tested on wheat and potato, both in the field and in pots. The performances due to urea, ammonium sulphate, ammonium nitrate, ammonium sulphate-nitrate and ammonium chloride on equal nitrogen basis were about the same. The ammonical nitrogen in all the fertilizers underwent almost total nitrification in 5-6 weeks in Delhi soil while in red soil the speed has been slower.

2. *Soil fertility due to continuous manuring and cropping in Pusa Permanent Manurial Experiments.*—Soils of the Pusa Permanent Manurial Experiments where continuous manuring and cropping have been done for the last 27-28 years were analysed. It was found that the total and water soluble lime, pH values and water soluble salts were not changed by the different treatments. Carbon and nitrogen contents are relatively high in better yielding plots. Soil deterioration was more pronounced in continuous cereal rotation plots than in no manure legume cereal rotation.

3. *Fertilizer value of dicalcium and semi-acidulated rock phosphate in calcareous soils.*—Field trials conducted for the fourth year on calcareous soils at Pusa with wheat confirmed the earlier findings that both these were as good as superphosphate.

Chemical analysis of the soils did not indicate any appreciable changes in the nitrogen and organic matter content in different plots. The total and available P_2O content were 10-20 per cent. higher in plots where any form of the phosphatic fertilizer had been applied every year at 80 lb. P_2O_5 per acre.

An experiment carried out on wheat in the field at Delhi showed that the response due to dicalcium phosphate was statistically comparable to superphosphate.

4. *Cowdung Gas Plant.*—Further trials on the utilisation of organic wastes in the plant for gas production necessitated certain modifications in the design of the drum as well as dimensions of the feeding pipe for effective operation.

Experiments on the use of the gas for lighting purposes showed that the intensity of light obtained is significantly increased by allowing the gas to pass through an enriching trap containing a small quantity of solvent oil or petrol. A simple indigenous burner which can be fabricated by farmers has been designed from an empty cigarette tin.

5. *Phosphate fixation and availability in laterite soils.*—Treatment of laterite soils with activated charcoal and EDTA showed that fixation of phosphate in such soils is not affected by alteration of soil reaction alone but complexing of sesquioxides markedly improves the condition. In pot experiments, response of barley to application of water insoluable phosphate carriers like dicalcium phosphate and processed bone meal was somewhat better than triple superphosphate. Treatments in which EDTA applied at 500 lb. per acre along with superphosphate, and lime applied at 8,000 lb. per acre with superphosphate gave a response of over 30 per cent. in each case. Maximum response of 63 per cent. was obtained when superphosphate was applied to soil treated with 10 tons of organic manure. Trichy rock phosphate at 1,000 lb. P_2O_5 (on the basis of total P_2O_5 in the fertilizer) also gave a high response of over 60 per cent. Sodium chloride at 500 lb. along with super gave a peculiar interaction and response of 65 per cent.

6. *Preparation of blood manure.*—Laboratory and semi-large scale trials showed that blood serum can be separately coagulated by adding about 1 per cent. $CaCO_3$, $CaSO_4$, CaO or superphosphate and just bringing it to boil. Blood clots can be effectively processed by boiling in 2 per cent. HCl or H_2SO_4 for only 5 minutes. The clots swell and become spongy and can be easily dried. The method completely eliminates foul smell. The dried manure from serum contains 11 per cent. nitrogen while that from clots 13·6 per cent. nitrogen.

7. *Effects of application of sodium chloride on paddy.*—In pot experiments on a soil of low N content, application of sodium chloride at 500 lb. per acre along 100 lb. N as ammonium sulphate gave 24 per cent higher yield of grain than ammonium sulphate alone. Compost at 100 lb. N gave no response but sodium chloride applied along with compost gave significant response. KCl substituted for NaCl in the above treatments at the same rate showed no significant effect.

(b) *Soil Microbiology*

8. *Studies on Azotobacter from acid soils.*—In a survey of Azotobacter conducted in the country *Azotobacter chroococcum* was found in Himachal Pradesh while *Beijerinckia* Sp. was found in the acid soils of Assam, West Bengal, Bihar and Kerala. The strains of *Azotobacter* isolated from acid soils differing in pH value from 4·5 to 6 fixed 8-11 milligrams nitrogen per gram of glucose in Derx medium.

9. *Effect of micro-elements on nitrogen fixation by Azotobacter.*—Molybdenum, cobalt, nickel and ferric iron have been found to stimulate nitrogen fixation significantly. The beneficial effect of cobalt at a concertration of 0·02 p.p.m on nitrogen fixation by *Azotobacter* was observed. The cells grown with cobalt in the medium was found to be richer in this element as compared to those grown without cobalt.

10. *Rhizosphere effects on micro-organisms.*—Investigations carried out in pots and in the field with berseem and wheat showed that there was a predominance of micro-organisms in the rhizosphere soil samples as compared to the soil samples collected from outside the root zone during the early stages of crop growth.

11. *Utilisation of wild legumes.*—Wild legumes *Dolichos lablab, Aeschynomene aspera* and *Phaseolous lathyroides* were found to be as readily nitrified as sunnhemp. *Aerschynomene aspera* is a widely available wild legume in the rice tracts of West Bengal and can be used as green manure in this tract. The amount of total nitrogen in the soil enriched by addition of these green manures was equal to that when sunhemp was used.

12. *Microbiological decomposition of herbicides and their effect on soil microbiological activities.*—Methyl-chlorophenoxy-acetic acid and 2, 4-dichloro-phenoxyacetic acid at concentrations between 1-20 lb. per acre did not affect nitrogen fixation or nitrification processes in the soil.

B. Soil Survey and Soil Physics

13. *Studies on Indian soils: Genesis, Morphology and Classification*
(a) *Black soils.*—A study was undertaken to investigate into the role of relief in the formation of black soils. Five profiles collected along the length of a continuous slope in Amraoti Farm (Bombay), a typical black soil area formed from basalt, show that the depth of the solum increases as well as the intensity of black colour of the soils deepens down the slope, dark grey colour being found in the depression. pH, contents of clay, calcium carbonate, and silica go on increasing regularly from the elevated position to the depression. The chemical composition of the soils and their clay fractions corroborate the same.

(b) *Alluvial soils.*—Investigations carried out during 1956-57 on the pedogenesis of some alluvial deposits in the plains of West Uttar Pradesh revealed mere stratification in younger formations while in the undisturbed older alluvium, there was horizon differentiation and profile development. Accumulation of clay due to leaching, sesquioxides, calcium and magnesium were observed in the intermediate horizons which could be provisionally designated as 'B' horizon. With these morphological and chemical data as basis, further studies were taken up in the Ganga-Yamuna Doab of South West Uttar Pradesh to evolve a genetic classification of the Ganga-Yamuna alluvium. In soils of Etawah, Phaphund, Shikohbad, and Etah, the horizon pattern and sequence were more or less similar to those observed in the soils of West Uttar Pradesh.

Saline-alkali soils examined in the irrigated tracts of South-West Uttar Pradesh revealed high soluble salt content and exchangeable sodium. Leaching of clay in the sub-soil, its compact and blocky structure and the exchange complex resemble the 'Solonetz' group of soils.

(c) *Black and associated red, yellow soils.*—Pedogenic study of various types of soils found in close locality in the Raipur district of M.P. was continued. The four types of soil found side by side are *Kanhar* (black), *Dorsa* (grey), *Matasi* (yellow) and *Bhata* (red or brown), derived from limestone, clay shale, and sandstones as parent materials respectively. Topography and parent material are the two most important factors in the genesis of these soils. While *Kanhar* and *Dorsa* are always found in the basins, *Bhata* is always found in the elevated topography, the *Matasi* occupying the intermediate position. *Kanhar* and *Dorsa* are formed by more weathering than the other two types of soil as evidenced from the data on free sesquioxides and is also corroborated from the chemical composition of the soils and the clay fractions.

14. *Studies on saline and alkali soils.*—Gypsum, in combination with organic matter, was found to be more effective in reclaiming alkali soils of a Delhi village than the individual treatment and gave large increase in yield of wheat over the control.

Application of both gypsum and krilium in an alkali soil gave increased yield. While gypsum had its significant effect in reducing the soil reaction, krilium had its effect in improving soil structure.

15. *Studies on soil structure*: (a) *Influence of soil conditioners on soil structure.*—Laboratory studies with krilium and sodium silicate in a normal soil of the Farm indicated that application of sodium silicate increased the pH of the soil whereas krilium had the reverse effect. Sodium silicate showed aggregating power only in higher doses which was followed by increase in pH.

In a field experiment conducted at the I.A.R.I. Farm, in collaboration with the Division of Agronomy, application of sodium silicate at a concentration of 0·15 per cent of showed slight improvement in soil aggregation. Aggregation in the treatments with castor cake, and farm yard manure was slightly higher than that of control, although not very significant.

(b) *Studies on Activite.*—Activite, an organic soil conditioner distributed by the U.S. Activite Corporation of Phoenix, Arizona, is a liquid produced as a result of fermentation of the solid and liquid excrement of lactating cattle. The material, it is claimed, has been found beneficial in flocculating the soil and decreasing its alkalinity. The following two experiments were carried out: (1) *Reclamation of alkali soils*: Experiments were conducted in the field as well as in pots, on a soil of pH 9·7. Activite was applied at a rate of 100 gallons per acre. Increase in yield of wheat with activite was 19 per cent. over control whereas with gypsum and krilium, the yield was respectively 72 and 60 per cent more over control, (2) *Permeability of heavy and alkali soils*: In case of heavy black soil passing through 2 mm., activite percolated slightly quicker than tap water. But the rate of percolation remained the same in the alkali soils, both with activite and tap water.

16. *Soil conservation studies*: *Run-off experiments.*—The object of the project is to study run-off of rain water and soil loss on a sloping land under different cropping practices from the point of view of soil conservation and better land utilization. Four run-off plots (each measuring 50′ x 5′) were set up along with collection tanks, evaporimeter, and automatic rainfall recorder etc. During this year all the plots were left fallow and observations recorded showed that all the plots behaved uniformly regarding run-off and soil loss. This was necessary for initial recording.

Total rainfall was 568·5 mm. Percentage of run-off was found to be approximately proportional to the intensity of rainfall. Total soil loss on uncultivated fallow was 3 tons per acre.

The soil in the run-off was more clayey and less sandy (clay-35 per cent silt-13 per cent.: sand-52 per cent.) as compared to the texture of the soils of the plot (clay-17 per cent.; silt-11 per cent.; sand-73 per cent.), thereby showing that clay was more susceptible to water erosion than the other mechanical constituents of the soil.

C. Physical Chemistry

17. *Fundamental studies on ionic equilibria in soils and plant roots.*—Studies on ionic equilibria in materials of different cation exchange capacities have shown that colloids of greater exchange capacity adsorb relatively less of monovalent cations as compared to divalents and unified in principle a number of apparently different subjects like the alkali hazards of different irrigation waters, the exchangeable potassium necessary to give the minimum activity for plant sufficiency in different soils and the compatibility of different plant mixtures under mixed cropping. The degree of sodium saturation developed in soils from Pusa, Suratgarh, Rudrur and Dharwar ranging in cation exchange capacity from 2·6 to 63·6 m.e./100 gm. in equilibrium with one and the same type of water was inversely related to their cation exchange capacity. Similarly the exchangeable potassium per cent. required for the soils from Hagari, Bangalore and Munsong to give equal activity of potassium in solution in the range of this activity, 0·25 to 3·4 m.e. per litre, was also inversely related to their cation exchange capacity. An analysis of the existing data has shown that mixed cropping of a cereal with a legume having a greater root cation exchange capacity than the cereal was successful in areas of less potassium supply or greater calcium, while the reverse was the case with the mixture of cotton and minor millets, which have a less cation exchange capacity than cotton itself.

18. *Studies on the formation of saline and alkali soils of Pusa and their reclamation.*—As a result of certain ameliorating measures *mung* and sugarcane grown as a mixed crop yields of 3 mds. and 400 mds. per acre respectively. The first periodical analysis in the laboratory has also indicated an improvement in the permeability of the sub-soil.

19. *Physico-chemical studies on the fertility of soils due to their clay-humus complexes.*—The co-efficient of correlation between the product of Group I x Group IIa clay-humus complex contents of the soil and the yields of wheat at Delhi in the soil fertility experiments of the Agronomy Division was found to be 0·86 which was significant at 1 per cent. level. In the old Permanent Manurial Experiments at Pusa, keeping the level of nitrogenous fertilization the same, the yield of wheat was found to be correlated with Group I clay-humus complex content. Laboratory experiments on the degree of aggregation of the clay and the amounts of clay-humus complexes in the various combinations of clay-minerals and organic manures that were incubated, showed that these fertility determining complexes could be increased by a suitable mixed soiling of the soil of one area with that of another depending upon their clay-mineralogical composition.

20. *Physico-chemical methods in the study of soils.*—A diffusion method of determining potassium ionic activity in the soils has been developed. Preliminary work to extend this to plant roots is in progress.

D. Plant Chemistry

(a) *Organic Chemistry*

21. *Pesticides.*—(a) Geraniol thiocyanoacetate, a thiocyanate derived from acyclic terpene when tested as a emulsion against *Lipaphis erysimi* at 1 per cent. concentration gave practically no mortality as against 100 per cent. and 97:8 per cent. mortality with isobornyl thiocyanoacetates

and nopyl-thiocyanoacetates respectively, both being the derivatives of cyclic terpenes.

It was reported earlier that longifolyl thiocyanoacetate has exhibited insecticidal property against some insects of economic importance and also showed slight synergism for pyrethrins. According to one of the processes for its production, the unreacted and isomerised sesquiterpene, obtained as by-product showed tendency to discolour and gum on standing. A simple method has been developed to stabilise the sesquiterpene. This will significantly help in the development of longifolyl-thiocyanoacetate as an economic insecticide.

(b) Chlorinated insecticides are known to be poor toxicants against aphids. The same behaviour was observed, when longifolyl hydrochloride further chlorinated so as to contain 31·7 per cent. chlorine, chlorinated pinenes with 52 per cent. chlorine, further chlorinated in the presence of iodine to 61 per cent. chlorine content and chlorinated delta-3-carene further chlorinated in presence of iodine to 63 per cent. chlorine content and nitrated trichlorobenzene (m.p.58°C) did not show any mortality in case of *Lipaphis erysimi Kalt.* in 24 hours.

Chlorinated delta-3-carene (Cl, 51·08 per cent.) corresponding to tetrachloride, when tested as adulticide against mosquitoes *Culex fatigans* and flies *Musca nebulo*, showed fair toxicity though to a lesser degree than D.D.T.

(c) *Synergists and insecticidal formulations.*—It was reported earlier that recovered sesquiterpene, obtained in the preparation of longifolyl-thiocyanoacetate, showed larvicidal action against *Culex fatigans*. Further work has been carried out in improving its film strength. Various adjuvants have been tried. Addition of 2 per cent. dibutyl phthallate has given the best result. However, the film on water even in this case was not so stable as that of standard larvicidal oil.

(d) *Synthetic pine oil.*—The pilot plant investigations for the production of terpene ethers and alcohols-synthetic pine oil, have been successfully completed at Shri Ram Institute, Delhi. Preliminary reports received from various users have been encouraging. Indian turpentine oil gave yields of 30-32 per cent. of terpene ethers and alcohols which resemble natural pine oil in chemical composition and physical characteristics. The unreacted water clear turpentine oil has better keeping qualities, than the original turpentine and can be used in its place as a thinner for paints and varnishes. The patented process for the production of synthetic pine oil has been licenced to two firms for commercial development.

(e) *Fungicides.*—With a view to develop non-toxic fungicides, zerumbone an alpha, beta-unsaturated ketone, present in wild ginger oil as well as ginger oil itself are being tested.

22. *Pesticides of botanical origin:* (a) *Pyrethrum.*—Work on the development of a rapid method for estimation of pyrethrin in flowers is being continued.

(b) Extractives prepared from neem, nerium, matricaria flowers did not show any toxicant action against *Tribolium castaneum* and aphids Extractive from roots of *Plumbago zylanicum* is being tested.

23. *Essential oil yielding spices of India* (I.C.A.R. Scheme).—In continuation of the work reported earlier a large number of ajwain, corriander, lennel, dill and cumin have been analysed for their volatile oil content. It is of interest to note that two strains of ajwain contained 7·8 per cent. and 8·5 per cent. of volatile oil as against an average of 3-4 per cent.

24. *Exploration of toxicity hazard in the use of modern insecticides*: (I.C.A.R. Scheme).—Methods for the estimation of insecticidal residues on plant materials have been standardised.

Storage of wheat grains treated with D.D.T. in the laboratory for more than six months showed the persistence of D.D.. at levels of 57·5 to 73·8 p.p.m. Winnowing and washing the grains, reduced the insecticidal content by about 90 per cent.

Vegetables treated with D.D.T. and B.H.C. dusts in the field have been found to retain small residues of the insecticide on harvest. Such residues are somewhat higher when the crops are treated with emulsions of insecticides rather than the dusts.

(b) *Biochemistry*

25. *Spraying of urea and phosphate on barley.*—In continuation of the work on wheat reported earlier, an experiment was taken up in pots to study the comparative efficiency of foliar and soil application of urea and sodium phosphate on barley. Three sprayings were given at young, flowering and post-flowering stages. Spraying of urea at 0·5, 1·0 and 1·5 per cent nitrogen levels showed increase in the yield of grains over water spray as control. Corresponding soil application at 0·5 and 1·0 per cent. nitrogen levels gave yields lower than that of the spray treatments with the same concentrations of urea while at 1·5 per cent. nitrogen level soil application gave higher yield. The nitrogen content of the grains increased with nitrogen treatments whether applied to the soil or to the leaves. Application of sodium phosphate to the leaves or to the soil also increased the phosphorus content of the grains. The comparative uptake of the nutrients applied to the soil or to the leaves is being estimated.

26. *Available micro-nutrients in the soil.*—It was reported earlier that application of certain micro-nutrients like copper, zinc, manganese to Delhi soil showed a significant increase in the yield and protein content of wheat in three consecutive years in the same field. The soil was not deficient in the total amount of any of these micro-nutrients. It was, therefore, thought to be of interest to estimate the available amount of these micro-nutrients in the soil. A bioassay method has, therefore, been developed by which the available amount of zinc, copper, cobalt and molybdenum can be estimated. The available zinc is being estimated in different typical soils of India. Besides, the mechanism of fixation of micro-nutrients when applied to the soil is also being studied.

27. *Mechanism of amino-acid synthesis.*—A survey of enzyme systems in germinated berseem showed the presence of enzymes, transaminase and aspartase. The transaminase preparation was found to catalyse the reactions between—

(a) Aspartic acid and α-ketoglutaric acid.

(b) Glutamic acid and pyruvic acid.

(c) Alanine and ∝ -ketoglutaric acid.

Paper chromatographic study of the free amino acid composition of root nodules of berseem showed the predominance of aspartic acid, glutamic acid, serine, asparagine and glutamine.

28. *Animal and plant proteins.*—The work on the *in vitro* digestion of plant proteins in gram, *mung*, lentil, *rahar, urid*, pea and that of animal proteins like meat and casein was continued. The digestion of meat and casein is faster than that of pulse proteins. Among the pulses, the digestion was maximum with gram followed by lentil, pea, *rahar, urid* and *mung*. Comparative studies on the nature of intermediary breakdown products of animal and plant proteins did not show any difference.

29. *Studies on plant enzymes.*—Mitochondria prepared from germinated *mung* bean has been found to oxidise ∝ - ketoglutaric acid but not glucose, while the mitochondrial preparation from germinated berseem oxidised a number of C_4 -dicarboxylic acids and also contained adenosintriphosphatase and pyrophosphatase activity. β- glycerophosphatase could not be detected in the same.

30. *Metabolism of Lactobacillus leichmannii.*—An activator required for the growth of *Lactobacillus leichmannii* was found in tomato juice. This activator could not be identified with any known substance and attempts were, therefore, made to purify the material. The activator has been found to be non-dialysable, stable to heat, precipitated by acetone, ammonium sulphate and the salts of heavy metals. It is destroyed by ashing and is not affected by ultra-violet irradiation.

Respiration experiments conducted in Warburg apparatus with organisms washed in the cold showed that none of the amino-acids are oxidised by this organism, while sodium pyruvate, sodium lactate and glucose are oxidised. The oxidation of glucose and lactate is not sensitive to cyanide and dinitrophenol whereas pyruvate oxidation is inhibited by both the inhibitors.

31. *Foliar application of nutrients to crops*: (I. C. A. R. Scheme).—A field experiment to study the effect of different concentrations of urea sprays on the yield and quality of wheat was conducted during the *rabi* season (1957-58) at Pusa (Bihar) and Indore (M.P.) centres. At Delhi pot experiments were done to study the comparative efficiency of urea, ammonium sulphate, ammonium nitrate and sodium phosphate when applied to the soil and sprayed on the leaves of wheat and tomato.

Experiments at Delhi on both the crops showed that foliar application of urea was better than that of ammonium sulphate and ammonium nitrate when applied singly or in combination with phosphate.

E. Physics

32. *Use of electrolytically pure copper rods for spectrochemical analysis.*—Copper electrodes are commonly used for the estimation of boron in soil and plant materials by spectrographic methods. Spec pure copper electrodes were in use in this laboratory. As these are not easily

available at present, it was thought desirable to use electrolytically pure copper rods if they are suitable for the work. Data collected with a large number of samples arced indicated that the electrolytically pure copper is quite suitable for spectrographic analysis and impurities, if any, are below the limits of interference.

33. *Micro-element status of typical tobacco growing soils of Guntur-Godavari belt.*—Guntur-Godavari belt is well-known for the production of virginia tobacco. Twenty four soil samples from different parts of the area were collected for the analysis of micro-elements. Of these six samples were collected in large quantities as to grow virginia tobacco at I.A.R.I. in pots. The soils were analysed for their physical properties, copper, cobalt and zinc. The leaf analysis also is in progress so as to assess the relative availability of these elements in the different soils studied.

F. Soil Testing

34. *Fertility status and fertilizer requirements of Indian soils as revealed by soil tests.*—Studies conducted on 20,000 samples throughout India show that 70 per cent of the soils are low in P content, 20·1 per cent medium and 9·9 per cent high. Available potassium is low only in 27·6 per cent. In the case of carbon and average nitrogen about 63 per cent are low. Only 1 per cent soils showed alkali nature and required reclamation.

35. *Fertility status and soil test summaries of some Community Project areas in India.*—The soil test summaries of the different community project areas showed considerable variation in their fertility status as revealed by soil tests. The nutrient index value gave a general trend of likely response in most of the soils. Prediction value appears to hold good in 60 to 110 per cent of the cases in different Community Project areas.

36. *Soil test summaries of Delhi State village.*—In Delhi State 57·1 per cent of the soils are low in phosphate while in the case of available potash only 37 per cent are low. About 5-10 per cent are either saline or alkali soils, both requiring reclamation measures. In the case of organic carbon content nearly 89 per cent of the soils are low.

Fertilizer demonstration trials in Delhi State villages show a significant difference with different treatment.

37. *Estimation of available nitrogen in soils and correlation with crop response.*—The study of release of ammonia under water-logged condition indicates that ammonia released under water-logged condition kept for one week gave a very significant correlation with crop response in Indian soils.

38. *Correlation of soil tests with crop response at different levels of phosphate application to wheat in Delhi soils.*—Experiments were conducted on wheat in the field and in the pots. Significant correlation between soil test values and yield as well as uptake of phosphate were obtained by both Olsen's method and Datta's versene flouride method.

39. *Studies on fluctuation in available nutrients with season, temperature and moisture changes.*—The available nutrients were found to be considerably affected by temperature and moisture level. In the case of water-logged soils, there is decrease in the availability.

40. *Hortico soil test kit.*—The nutrient status that can be assessed with the help of Hortico kit show that phosphatic fertilizers are the primary need of *guar* and berseem in Delhi soil in addition to phosphate, copper and manganese which are necessary for guar and berseem respectively.

41. *Establishment of soil testing laboratories.*—Under the Indo-U. S. Operation Agreement No. 4, fifteen soil testing laboratories have been established all over India. Nine more will start operating soon. More than 33,000 samples of soil have been analysed in these laboratories.

G. Radio-Tracer Investigations

42. *Phosphorous fertility status of soils—radiotracer and related investigations.*—(a) *Available phosphorous in soils and phosphorus fertilizer utilisation by rice, wheat/oats.*—Percentage utilisation of applied phosphatic fertilizer by wheat, early rice and late rice grown on different soils varied from 8-16, 2-9 and 2-20 per cent respectively. Degrees of phosphorus unsaturation in these soils calculated as—

$$\frac{\text{Anion exchange capacity—exchangeable P}}{\text{Anion exchange capacity}} \times 100$$

were found to correlate significantly at 1 per cent. level with percentage utilisation of labelled superphosphate. It appeared that the amount of phosphate the plant can utilize from applied soluble fertilizer is related to the degree of saturation of the anion exchange complex when the soil is only slightly saturated in respect of P. C/A ratios, according to Mehlich, determined for the soils varied from 0·5 to 2·4 indicating that the mineral colloids in the soils fall in categories: halloysite, kaolinite, illite and beidellite.

(b) *Measurement of surface P of soils—isotopic exchange with* P^{32}. Measurement of surface phosphorus was attempted by the method originally suggested by McAuliffee *et. al.* (1948) and later improved by Olsen (1953). It was found that in a number of soils, concentration of phosphorus in aqueous phase at equilibrium was too low to be accurately estimated by known methods. For a number of other soils, the P^{32} solid/solution when plotted against time gave a zig-zag curve which would not allow accurate reading of this ratio at the suggested arbitrary 60 hour period. However in a number of other soils these difficulties were absent and surface phosphorus was found to be significantly related to available Phosphorus by 0·5 M $NaHCO_3$ method.

(c) *Placement studies with tagged superphosphate on linseed.*—This is a collaborative experiment with the Agronomy Division. Tagged superphosphate was placed in various ways in relation to the seed. Samples were drawn at 30 days and 60 days growth for analysis. It was found that at 30 days, percentage uptake of phosphatic fertilizer was maximum from single band application 3″ below seed and single band application

1″ below seed. Fertilizer phosphorus uptake from surface application was much less (the figures were 53 per cent, 50 per cent, and 5 per cent from 3″ below seed, 1″ below seed and surface application respectively). At 60 days growth, however, the percentage uptake of fertilizer phosphorus was maximum from double band 3″ below seed and 2″ to the side. Surface application was again low (the figures were 52 per cent, 23 per cent and 10 per cent respectively for the three modes of application). From the uptake pattern it appears that the roots grew vertically in the initial stages of growth and later spread sidewise also.

(d) *Fixation, exchange and movement of tagged phosphorus in soils.*—A new technique for radioautographic study of movement of phosphorus in soils was developed. The method uses split plastic tubes with sutures sealed with cellophane tape. These were found to be better leaching columns for subsequent sectioning for radioautographic study. After the experiment the cellophane tape was cut along the seams by a sharp edged blade. A stretched steel pianoforte wire passed through the soil column then gave smooth uncontaminated soil sections. This eliminated the necessity of sliding soil columns out of leaching tubes and freezing for subsequent sectioning by bandsaw. The method along with accessory leaching apparatus and camera also developed, is adaptable for use on six or more soils in one run. A moulded aluminium sheet sliding along the collar of the sectioned half in the camera was used to cut off beta radiation coming from contaminated upper part of the perspex column.

Movement of tagged fertilizer phosphorus in a number of different soils under different treatments has been studied with this method. The depth of movement was found to be minimum for heavy soil having high free sesquioxide content and maximum for light soil of low content of free sesquioxide. The effect of bulky organic matter was to significantly increase the movement in all the soils but the greatest affect was in black cotton and the alluvial soils. In the case of laterite soil flooding treatment which created reducing conditions was as effective as organic matter in increasing phosphate movement.

(e) *Comparative efficiency of different phosphatic fertilizers.*—Tagged superphosphate, mono and dicalcium phosphates, calcium metaphosphates. mono and diammonium phosphates and ammoniated superphosphates were tried on green house wheat grown on alluvial, black cotton and laterite soil. It was found that in general, monoammonium phosphate was more efficient than other carriers tested. Super and diammonium phosphates were next in order.

Programme of work for 1958-59.

Soil Fertility

1. Fertilizer response in respect of yield of crops and uptake of nutrients.

2. Effect of dipping of roots of paddy seedlings in nutrient solutions before transplanting on growth and yield.

3. Studies on the changes in carbon and nitrogen during decomposition of organic matter and added organic manures.

4. Study of the effect of continuous manuring and cropping on soil fertility in Pusa permanent manurial series.

Soil Microbiology

1. Ecology of acid tolerant Azotobacter.
2. Studies on nitrogen fixation by Azotobacter.
3. Activation of Azotobacter.
4. Studies on Rhizobium of wild leguminous plants.
5. Nitrogen transformation in soil using stable isotope N^{15}.
6. Development of efficient strains of root nodule organisms.
7. Effect of micro-nutrients on micro-biological activities.

Soil Survey and Soil Physics

1. Studies on Indian soils: morphology, genesis and classification:
   (a) Black soils.
   (b) Alluvial soils.
   (c) Laterite and Latritic soils.

2. Mineralogical studies of soils and parent materials.

3. Studies on saline and alkali soils, irrigation waters and their improvement.

4. Studies on soil structure:
   (a) Influence of soil conditioners on soil structure.
   (b) Effect of grasses and ley-farming on soil structure.

5. Soil Moisture studies:
   (a) Determination of pF curves of Indian soils.
   (b) Standardisation of permeability measurements with different soils.

6. Soil conservation studies: Run-off experiments.

Physical Chemistry

1. Studies on the ionic exchange in soils, clays, clay minerals and plant roots.

2. Electro-kinetic properties of alumino-silicate precipitates, clay minerals and soils in relation to formation of clay minerals.

3. Studies on the separation and properties of clay and clay, humus complexes from soils.

4. Studies on the activities of ionic nutrients in various types of soils, clays and clay minerals in relation to their availability to plants.

Organic Chemistry

1. Synthetic pesticides:—Synthesis of organic compounds containing various toxophoric groups as possible insecticides; synergist for insecticides; formulations of pesticides; fungicides and weedicides.

2. Pesticides of botanical origin:—Improvements in pyrethrum and examination of indigenous plant materials for pesticides.

3. Exploration of toxicity hazards in the use of Modern insecticides—(I.C.A.R. Scheme).

4. Improvement of essential oil yielding spices of India (I.C.A.R. Scheme).

Biochemistry

1. Nitrogen metabolism in the plant.
2. Mechanism of biological synthesis of enzymes in the plant.
3. Available micro-nutrients in the soil.
4. Studies on plant nutrition.
5. Foliar application of nutrients to crops (I.C.A.R. Scheme).

Micronutrients and Physics

1. Standardisation of spectographic, spectrophotometric and polarographic methods of estimation of micro-elements.

2. Microelement status of Indian soils and their uptake by different crops.

3. Qualitative identification and quantitative estimation of clay minerals in soils by X-ray diffraction technique.

4. Electron microscopic studies of clay minerals and viruses for their identification.

Soil Testing

1. Preparation of soil test summaries of Delhi State and on all India basis.

2. Studies on correlation of soil tests with crop responses in green-house studies and field experiments.

3. Fluctuation in available nutrient with season, crop growth and moisture content.

4. Comparison of different soil test kits for assessing their relative use in Indian soils.

Radiotracer Investigations

1. Available phosphorus in soils and phosphorus fertilizer utilization by rice, wheat—a green-house *cum* laboratory study with radioactive phosphate.

2. Measurement of surface phosphorus of soils—isotopic exchange with radio-active phosphorus.

3. Comparative efficiency of different phosphatic fertilizers through radiotracer studies for wheat and rice on major Indian soils.

4. Effect of moisture levels, organic matter, silicates and chelates singly and in combination on uptake and utilization of phosphatic fertilizers by wheat, rice and berseem.

5. Spray fertilization of phosphatic fertilizers *vs.* normal application.

6. Radio-avtive carbon in the study of decomposition of bulky organic matter in soils and nutrient availability.

REPORT OF THE DIVISION OF AGRICULTURAL ENGINEERING

(SHRI E. G. K. RAO)

GENERAL

(a) The following machines and implements were received during the year for tests and trials:—

S. No.	Name of Machines or Implements	Received from
(*i*)	Bullock-drawn light Swing plough with gauge Wheel.	M/s. Light Carts, Meerut Cantt.
(*ii*)	Super type K 212 grain dressing and seed cleaning machine.	M/s. Meerut Development Corporation (Pr.) Ltd., Meerut Cantt.
(*iii*)	Hand operated bellow duster . . .	Assistant Agricultural Engineer (Research), Bapatla.
(*iv*)	Land Master Walking tractor . . .	M/s. Wilcox Buckwell (India), Ltd.

(b) Whenever required, other Divisions of the Institute were advised on specification, purchase and selection of engineering stores including farm machines and equipment. The Central Office, Library and Hostels were assisted in the purchase of furnitures and fittings by inspecting the stores offered.

(c) The Agronomy Division was assisted in carrying out the repairs of tractors, steam engines, oil engines etc., and also farm implements and machines under their charge.

(d) The Activated Sludge Plant had been under the technical and administrative supervision of this Division throughout the year.

SCHEMES

(i) *Museum of Agricultural Implements and Machines*

The building for housing the Museum has been completed and handed over to this Division recently. The exhibits so far collected in the Division from different sources, are now being arranged in the building. Arrangements for recruiting the staff sanctioned for the scheme are also being made.

(ii) *Production, Demonstration, Trial and Popularisation of Improved Agricultural Implements.*

Although the scheme was extended for compiling the test reports of the different implements which were supplied earlier to the various State Governments under the scheme, from 1st April 1957, the work could not be taken up during the year under report due to the non-availability of the sanctioned staff. It is expected that the staff would be recruited within a short time and work of the scheme would be started.

(iii) *Survey of Indigenous Agricultural Implements in Common Use in the Country.*

The scheme was due to expire on 31st March 1958, but it has been extended for six months from the date as the work of compilation of the All India Report had to be completed. The work pertaining to the preparation of the Report is progressing according to schedule and it is hoped that the work would be completed within the specified time.

RESEARCH

I. Development of Sowing and Fertilising Machines:

(i) *Bullock drawn seed drill.*—A bullock drawn single furrow seed-drill was designed and fabricated by this Division and was put to test in the field. In the beginning the drill did not work satisfactorily due to wheel slippage and non-penetration of the furrow openers. After some adjustments, however, it was possible to drill 2 to 3 seeds in one place at an average distance of 9"—10". None of the seeds were damaged and as a result it was found that all seeds sown had germinated. As the performance of the machine was considered satisfactory, a four-row seed drill of the same design was also fabricated and it is awaiting extensive field trials.

Another model of a four-row seed-drill with fluted roller type seeding attachment has also been developed. This machine is designed for operation on four furrow openers and a wheel which has been provided at the rear of the drill for obtaining the drive. The furrow-openers can be lifted up for transport, when required. This machine is also waiting for field trials.

(ii) *Fertilizer Placement*-cum-*sowing machine.*—A fertilizer placement *cum* sowing machine has been designed and fabricated in the workshop. The seed *cum* fertilizer-box of the machine has separate chambers for storing seed *cum* fertilizers. The seeding machanism is of the fluted roller type and that of the fertilizer distributing is of worm type. Preliminary trials of the machine were successful. It is now awaiting extensive trials in the farms of the Agronomy Division.

II. Experiments with Winnowers and Winnowing Fans:

(i) *Japanese Winnower.*—A hand operated Japanese Winnowing Machine was tried in the Division with various grains. The winnower, the frame of which is made a good seasoned light wood and covered with thin G.I. sheets on sides, is simple in construction. The winnowing mechanism consists of a fan made of four wooden blades set at right angle to shaft. The fan is mounted on an axle which is supported on wooden bearings. A hopper with adjustable opening is provided on top of the machine for feeding purposes. Two outlets have been provided for passing out clean and partially clean materials, on the sides of the machine.

The machine was tested for winnowing wheat, gram, maize and shelled paddy. It was also tried for separating shells from the decorticated groundnuts and Mohuwa seeds. The performance of the machine was found to be satisfactory. It was however observed during the tests that the machine could winnow any material whose chaff, shell, husk

etc., are sufficiently small in length and in no case bigger than the width of the hopper gate opening.

(ii) *Winnowing Fan.*—Three types of winnowing fans, namely the Bombay (gear type), the Punjab (chain drive type) and the I.A.R.I., fans were tested for comparing their performances. All the three fans were worked for winnowing threshed wheat under identical conditions. The observations made during the trials are tabulated below:

Output Total Qty.	Bombay Fan	Punjab Fan	I.A.R.I. Fan
Winnowed per hour	178 lbs.	244 lbs.	256 lbs.
Output of wheat	46 lbs.	60 lbs.	64 lbs.
Output of Bhusa	132 lbs.	184 lbs.	192 lbs.

III. Experiments with bullock-cart axles and bullock-gear:

(i) *Improved cart axles.*—Tests on country carts fitted with axles and hubs with ball bearings manufactured by Messrs. National Emporium, Roorkee, were carried out for recording the draft required for pulling the cart on Kucha and pucca roads under different loads in order to compare the working with that of the conventional country cart under similar conditions.

The following data was collected during the tests:—

Conventional Cart					Cart fitted with improved axle from N.E., Roorkee			
Wt. of cart on axle	Payload in lbs.	Speed miles/ hour	Dynamo meter reading	Road	Wt. of cart on axle.	Pay load in lbs.	Speed mile/ hour	Dynamo-meter reading
954 lbs. . . .	1230 lbs.	2·36	75 lbs.	Pucca	954	1230	1·84	75 lbs.
,, . . .	,,	3·00	80 ,,	,,	,,	,,	3·0	85 ,,
,, . . .	,,	1·74	145 ,,	Kucha	,,	,,	2·08	160 ,,
,, . . .	,,	2·44	150 ,,	,,	,,	,,	3·2	167·5 ,,
,, . . .	1640 lbs.	2·06	85 ,,	Pucca	,,	1640	1·8	92·5 ,,
,, . . .	,,	3·01	92·5 ,,	,,	,,	,,	2·95	96 ,,
,, . . .	,,	2·25	170 ,,	Kucha	,,	,,	2·03	178 ,,
,, . . .	,,	3·25	185 ,,	,,	,,	,,	2·98	190 ,,

The conventional cart appears to be slightly superior to the cart fitted with improved axles so far as the draft required for pulling it is concerned.

IV. Experiments with Harvesting Implements

(i) *Scythes.*—At the instance of the I.C.A.R., a few types of scythes received from Austria, were tried last year in this Division. A few more scythes with different shapes of handles were received from the F.A.O., Rome, under the exchange of implements plan, for tests and trials. These scythes were tested for harvesting green berseem and oats. The data collected during these trials are given below:—

S. No.	Crop harvested	Scythe with iron handle		Scythe with New wooden handle		Scythe with Austrian handle	
		Area of plot in sq. ft.	Time taken in mts.	Area of plot in sq. ft.	Time taken in mts.	Area of plot in sq. ft.	Time taken in mts.
1.	Green Berseem .	1232·00	5·00	900·00	4·50	..	..
2.	Do. . .	748·00	7·00	588·00	8·00	759·00	9·00
3.	Oats . . .	980·00	11·00	1295·00	14·00	..	..

Further trials of the scythes would be continued with other crops.

(ii) *Spinmax Lawn Mower.*—The 'Spinmax' lawn mower was received from a local firm for tests. The machine was tested in different lawns of the Institute and found to be satisfactory. The machine is equipped with a self-sharpening cutting blade and devices for adjusting the length of cut. The handles are provided with rubber grips and their height can be adjusted suiting to the height of the operator. A grass box is also provided at the rear of the cutting blade. The cost of the machine is low in comparison to other machines available in the market and therefore it is suitable for individual ownership.

V. Experiments with processing machines

Japanese Rice Polisher.—The Japanese rice polisher, which was tested earlier in the Division and found quite efficient for the purpose, was also tried for threshing Hubam clover (grass) seeds. It was found during the trials that the outer shells of the Hubam clover seeds could be removed by this machine quite efficiently and satisfactorily without damaging them. It was also observed that while it reportedly required 96 man-hour to thresh out a maund of Hubam clover seeds by hand methods, it took only 15 minutes to do the same job with the polisher. In view of the success attained in the present series of tests, it has been decided to continue the trials with seeds of some other grasses also.

VI. Experiments with Tillage Implements

(i) *Mould-board ploughs.*—Two mouldboard ploughs, one obtained from F.A.O., Rome, under the exchange of implements plan and the other from the East Germany (stall in the Indian Industries Fair—1955) were put to test. The details of the tests are as follows:—

(a) *German plough.*—During the trials, it was found that the German plough did not require the guidance of the ploughman while it was in operation in the field except at the turnings, provided it was properly

adjusted and aligned. It is an all-steel plough provided with a hitch and a two wheeled carriage for guiding the plough behind the bullocks. With some slight modifications, the plough could be easily transported from place to place. This was the major difficulty in the past in using this implement. The plough was tried in a field which was left fallow for the last two years. The following are the data collected during the trials:

S. No.	Furrow size	Draft in lbs.	Speed of bullocks in ft. per minute	Unit draft	Horse Power
1	9″ × 3″ deep . .	230	105	8·50	0·52
2	9″ × 4″ deep .	242	105	6·72	0·72

This plough and the carriage appear to hold out possibilities of evolving an integrated set of field implements for bullock operations. The possibilities would be explored in due course.

(b) *F.A.O. plough.*—This plough is also an all-steel plough with two bottoms fitted with slip type of shares and general mould-boards. A knife coulter and a gauge wheel for facilitating its transportation from place to place have also been provided with the plough. This plough was tested in a land from which *rabi* crops were harvested a few days ago. The test data is tabulated below:—

S. No.	Furrow size (Depth × Width)	Draft in lbs.	Speed of bullocks in ft. per minute	Unit draft	Horse Power
1	3½″×8″. . . .	260	120	10·00	0·98
2	3″ ×8″	254	120	9·78	0·96
3	4″× 8″	274	115	8·56	0·92
4	4″ ×8″	278	110	8·70	0·92

It was observed during the above tests that both the ploughs were heavier in draft than the Victory plough which has the same size of bottoms. Further trials of the ploughs are in progress.

(ii) *Leveller.*—A bullock-operated wooden leveller was designed and fabricated. Some defects in its working were noticed during the field trials. Consequently the project was given up and a new leveller, based on the design of a tractor-drawn American leveller, has been taken for fabrication. The new leveller would be tried in field as soon as the manufacture is completed.

VII. Appliances for use with Cow-dung Gas

(i) *Chula.*—This Division is working in collaboration with the Chemistry Division in connection with the development of the simple labour saving devices and appliances to use cow-dung gas. As a result of a number of experimentations, a simple village model 'chula' (stove) has

been designed and fabricated. The main feature of the 'chula' is the wide range of control of flame size and the possibility of using cheap local material. The gas is admitted to the base of cylindrical container filled with stone pieces. The gas rising through the layer of stone diffuses over a large area and the flame burns in a stable manner over the bed of stones within a wide range of gas feeds. The device is now under extensive experimentation with a view to evolving an improved model.

(ii) *Lamp.*—Experiments are in progress with the object of evolving a satisfactory incandescent lamp using cow-dung gas under low pressure.

VIII. Appliances for preparation of land for Irrigation and water measuring Devices

(i) *Bullock-drawn Scraper leveller Blade.*—A bullock-drawn scrapper leveller blade has been fabricated on the basis of a design received from T. C. M. This is a well constructed wooden blade provided with a steel cutting edge and a control handle to alter the angle of attack of the cutting blade. The operation can cut earth from high spots, transport it and dump the load in the low spots at will.

(ii) *Bullock-drawn Float.*—A bullock-drawn float or land smoother was fabricated on the basis of a design received from the T. C. M. Wood is used in its construction and the device is provided with reinforcing tie bars made of Mild steel. The device is used to smooth and level the seed-bed in irrigated culture. The implement is quite effective, but it was thought that its performance could be improved by adjusting the weight distribution. An experimental model is being evolved to study the best weight distribution for efficient working.

(iii) *Bullock-operated Border Ridger.*—A border ridger which is meant for constructing irrigation field borders and head ditches, is under fabrication. This device is also based on an American design supplied by the T. C. M.

(iv) *Water Measuring Flume.*—Accurate control and measurement of water is essential for efficiency in irrigation and conservation of irrigation water. A parshall Flume with 6″ throat has been fabricated to measure small water flows.

IX. Intensive cultivation scheme

The following work has been done in different villages under the Intensive Cultivation Scheme by this Division during the year under report:

Ploughing (by tractor)	36 acres.
Ploughing (by M. B. Ploughs)	976 acres.
Discing (by tractor)	27 acres.
Sowing (by tractor)	144·5 acres.
Threshing (by olpad thresher, Ludhiana thresher and Disc Harrow)	2795 maunds of grains

One acre of land was levelled by using tractor and Buck-scraper to demonstrate the soil conservation methods.

Cow-dung gas lamps were demonstrated and maintained in 4 different villages, namely, Nangloi, Qamaruddin Nagar, Baprola and Hasthal.

X PROGRAMME OF WORK FOR THE YEAR 1958-59

1. Development of a bullock drawn seed-drill (contd).
2. Development of a bullock drawn fertilizer placement machine (contd).
3. Improvement of 'Olpad thresher' (contd.).
4. Development of a bullock operated leveller (contd.)
5. Development of heating and lighting appliances for use with cow-dung gas plant.
6. Development of a bullock gear.
7. Testing of agricultural implements and machines for use under local conditions.
8. Study of water logging and rise of water table at I.A.R.I.
9. Study of various modern methods of irrigation and their efficiency in co-ordination with Division of Agronomy.
10. Study of farm structures, storage structures and rural housings.
11. Study of possibility of improvements of irrigation implements and water lifts.
12. Any other work suggested by the Ministry.

Head of the Division of Agricultural Engineering.

REPORT OF THE INTEGRATED SCHEME OF ALL INDIA SOIL AND LAND USE SURVEY

(DR. S. P. RAYCHAUDHURI)

A scientific survey and classification of the soils of the country is urgently needed for a proper understanding of the kinds of soils existing and their exploitation for maximum advantage and rational land use. Since the practical aspects of soil science depend on certain fundamental concepts about genesis and classification, it is essential to understand how soils are formed and their extent in each region.

The aim of the soil survey is to (1) classify and map the different kinds of soils so that proper management and agricultural use of the soil resources can be planned and (2) apply the result of the research to individual field or tracts of land. With this aim in view the All India Soil Survey Scheme was started in 1956.

Four zonal centres were set up in four major groups of soils in India *viz.*, (1) Alluvial Soil Zone, (2) Black Soil Zone, (3) Laterite Soil Zone, and (4) Red Soil Zone. The kind of Soil map envisaged in this scheme was of a reconnaissance type generally in the scale of 1 inch = 1 mile.

With the integration of the All India Soil Survey Scheme with the Land Use Survey and Planning Scheme of the Central Soil Conservation Board since 1st March 1958, all the soil survey have been now centralised under one agency, *viz.*, the Integrated scheme of All India Soil and Land Use Survey. This has brought considerable change in the plan of work. The important change is the change of the region from soil basis to

geographical basis. The soil survey will now generally be standard detailed soil survey employing a scale of 16″=1 mile, or 8″=1 mile. Reconnaissance soil survey (1″=1 mile) will also be occasionally used to fix up the soil type and soil series. Dr. C. E. Kellogg, eminent soil scientist from U.S.A. who visited this country, has recommended this arrangement.

The broad objectives of the Integrated Scheme of All India Soil and Land Use Survey are both basic and applied. The basic soil survey is to classify and map out different kinds of soil to understand soil differences and to organise the body of knowledge of soils in order to lay down standards of legends, nomenclature, terminology etc. On the other hand the applied part of soil survey will include soil conservation survey, irrigation survey and the like to enable the land use plan. It also envisages the formulation of a national policy and procedure for all phases of the national soil survey and the cartographic activities, the development of national standards including soil survey operation, soil survey interpretation, soil classification and correlation, soil survey investigation and the standardisation of methods and procedures for improvement of these activities.

The specific applied objective of the present scheme is to conduct immediately soil conservation survey for land use planning of the catchment area of 78,000 sq. miles of the six river valley projects *viz.*, Kosi, Damodar, Chambal, Bhakra-Nangal, Hirakud and Machkund. The target is to survey and prepare land use maps of an aggregate area of nearly 15,00,000 acres annually.

Besides it is contemplated to carry out a detailed soil survey of the major groups of soils in India with priorities in areas to be irrigated and in areas where soil conservation work is being carried out or is contemplated. The Central Soil Conservation Board has been financing this scheme with the Headquarters at the Indian Agricultural Research Institute, New Delhi, under the Director, through a Chief Soil Survey Officer, with four Soil Correlation Centres, *viz.*,

(1) Alluvial Soil Region—Indian Agricultural Research Institute, New Delhi.

(2) Black Soil Region—Nagpur.

(3) Red & Laterite Soil Region—I, Kharagpur (at present Calcutta).

(4) Red & Laterite Soil Region—II, Bangalore.

Besides there is a cartographic laboratory at Indian Agricultural Research Institute to procure and print field maps of soil survey.

The progress of work for the above soil correlation centres, during the year under report, is given in the following pages.

Alluvial Soil Region, Delhi

During the year under report this region has completed reconnaissance soil survey (1″=1 mile) of two National Extension Block, namely (A) N.E.S. Block Banga Distt. Jullunder—Panjab and (B) N.E.S. Block Sohwal, Distt.—Satna, Madhya Pradesh. The soils have been classified into associations and series and the soil maps have been prepared for the Nawanshahar and Banga N.E.S. Blocks comprising a total area of 1,92,000 acres. The soils covering 1,31,000 acres of Sohwal N.E.S. Block have been classified and mapped. The soils of these blocks have been described below:

A. *Soils of N.E.S. Block Banga, District—Jullundur, Punjab.*—The whole expanse of gently sloping plains is formed of comparatively recent alluvial deposits, several hundred feet deep, and laid down by rivers and streams draining Himalayan Range. The soils have acquired certain morphological features which essentially reflect the influence of environment. For example, differences in drainage and physiographic position have partly affected the morphology and the salt concentration within the profile. The soils have been classified into the following units.

1. *Naura series—Normal soils.*—These soils are found on the uplands or "Dhak" and are generally fairly well drained. This group of soils form about 60% of the total. These alluvial deposits have not undergone any drastic change by way of erosion losses or by addition of fresh sediments during the last few centuries. So these soils have acquired certain morphological features due to the interaction of climate. Because of good rainfall and free drainage the soils are free of excess accumulation of soluble salts or calcium carbonate within the root zone. However, a layer of calcium carbonate accumulation in the form of Kankar nodules is invariably present at the depths, varying from 4 feet to 8 feet. The subsurface layer usually abounds in small iron-manganese concretions.

2. *Naura series—Saline phase.*—Main distinguishing features of the soils are (a) presence of a compact and hard layer of kankar nodules at a depth varying from 2½′ to 4′, and (b) high percentage of soluble salts in the profile. These soils occur in an imperceptible depression running continuously towards north west. During dry periods the salts are deposited on the surface in the form of crust or efflorescence. Imperfect drainage because of cemented kankar layer, and a high percentage of salts interfere with the growth of most of the normal crops and permit only a limited group of grass which can tolerate these conditions.

3. *Naura series—Saline—Alkaline phase (recently water logged).*—These were the normal, well drained cultivated soils akin to soil group No. 1 only a few years back. These soils occur in the northern part of the block and were the first to be affected because of general rise in the water table brought about firstly by an increase in the average rainfall from 30″ to 45—50″ and secondly by the advent of canal system which is supplying big volumes of water to an already saturated area. If the ground water table continues to increase these soils will soon be converted into marshes and bogs. Soils where water is not on the surface but

within the capillary rise range, have also been adversely affected and show efflorescence of salts on the surface during dry periods.

4. *Bhaura series.*—These soils occur in a narrow strip running on both sides of the white Bein. These soils remain under the stagnant water condition during and after rain. The soils are utterly stiff and tenacious swampy lands when wet these soils are in puddled and poor physical condition unfit for any field operation. On drying, these soils become extremely hard and develop cracks.

5. *Rahon series.*—This is a narrow, zig zag strip of coarse sand starting from the bed of river Sutlej and running north west and then west for about 5 miles. The soils are a loose mass of coarse sand which is of grey colour on the surface and changes to reddish brown with depth. The soils become very hard on drying because of cementation by iron oxides. The soils have very low nutrient level and their power of holding water is very little.

B. *Soils of N.E.S. Block Sohawal, District-Satna, Madhya Pradesh.*—The soils of this area range from deep, light gray brown and very dark gray brown clays to very shallow strong reddish brown upland gravelly sand with shales. They show a strong influence of geology and or topography and have easily recognisable features. The morphological features of the profile show a close relation with the parent material. Hence the main soils of this area are classified according to the nature of the parent material. The soils are classified as associations and series as described below.

1. *Rewra Association*—(a) *Rewra series.*—Very dark gray brown clay (without lime kankar in the top layers but kankar accumulation in the lower layer)—These soils are developed from the limestone and are dark gray in colour and clayey in texture. Clay content varies between 52.0 to 42.0 p.c. The pH of the soils varies from 7.8 to 8.0 and increases with depth of the profile. Total soluble salts are low (0.028). Usually there is an accumulation of organic matter in the surface layers which decreases with depth. The lime kankars are invariably present throughout the profile, kankar accumulation is at the bottom layers ($CaCO_3$ increases from 1.0 to 10.0 p.c.) with depth.

(b) *Barha Series.*—Light brown grey loam—These are shallow soils developed on limestone but no carbonates are found in the profile depth. The top layer is light brown grey in colour but second layer is dark grey brown.

(c) *Amdari—Kolgarhi series.*—Light brown gray clay loam—These are fairly deep soils developed on lime stone. The lime kankars are absent in the top layers but accumulated in bottom layer. Brown mottlings are present on the surface or top layer.

2. *Sohawal Association.*—Two types of shales are met in this area (i) soft clayey shales with bluish colour and (ii) Strong reddish brown and hard brittle shales. The soils developed on them are of following two types.

(a) *Khamaria—Sithpura series.*—Gray brown clay loam (carbonate absent throughout the profile)—These soils developed on bluish shales are moderately shallow, about 24" deep, gray brown on the surface, light olive brown in the middle layers and light brown gray to gray brown in lower-most layers where the bluish shales are associated. These are clay loam to clayey soils and the clay content varies between 28.0 to 48.0% within the profile which increases with depth of profile except the lower layer where there is a sharp decrease due to the presence of broken shale gravels. The pH increases with depth (6·1-7·9). Soluble salts are very low and carbonates are absent.

(b) *Mahadewa series.*—Reddish brown gravelly sand (carbonate absent throughout the profile)—These soils developed on the red shales are shallow, about 12" to 18" deep sandy loam. The shales are of dark reddish brown colour and the soils bear a reddish brown colour. pH of the soils is 6.5. Total soluble salts are very low and carbonates are absent.

3. *Soils of mixed origin.*—Where calcareous rock is associated with shales the mixed type of soils are found.

(a) *Gunhar series.*—Pale brown to light yellowish brown, clay loam—These are pale brown to light yellowish brown soils at the surface layer becoming gradually gray brown in the middle layers and then to light olive brown in the last layer. The texture is clay loam (clay varies from 25 to 45%). pH of the soil varies from 6.5 to 8.1 and increases with the depth. Soluble salts are low (0.014) in the upper layers but are accumulated in the bottom layers below 5 feet (0.0[illegible]). Lime kankars are accumulated in the lower layer below 5 feet (49% $CaCO_3$) but are absent in upper layers.

(b) *Pataora series.*—Pale brown sandy soils. Near the foothills this type of soil occurs. The lime kankars are absent in the upper layers but are accumulated in the lower-most layer at the depth of 5-6 feet.

(c) *Survey of Catchment areas.*—Bhakra-Nangal River Valley Project.—The soil survey staff appointed for soil conservation survey have been sent to the field after five weeks' preliminary training. Work has been taken up by stationing the parties at three centres namely Swarghat, Bilaspur and Sundarnagar. Preliminary reconnaissance of sub-catchment areas in these three places has been completed and materials for base maps have been assembled.

Black Soil Region—Nagpur

The districts of Poona, Ahmed Nagar, Nasik and West Khandesh were traversed as a preliminary to actual survey. Soil samples were collected from representative areas and laboratory analysis was carried out for different constituents.

A detailed reconnaissance soil survey of Nasik district was started and continued during the year. Survey of seven Talukas namely: Malegaon, Balegaon, Chandor, Nandgaon, Yeola, Niphad and Sinnar were completed. A total area of 22,37,317 acres has been surveyed.

Soils of Malegaon Taluka.—The area of 478, 812 acres was traversed and in all 78 profiles were examined and soil samples were collected from these profiles. The following types of soils occur in this region.

(i) *Shallow reddish brown sandy loam.*—Colour varies from 5YR 3/4 (dark reddish brown) to 5YR 3/3 (dark reddish brown). These are mainly of single grain structure with entire absence of lime even upto the parent material. The depth varies from 3 to 9 feet. This type of soil occupies the greatest part of taluka and the soils are almost barren. A large portion of this area is left uncultivated as the out-crops of the parent rock are observed on the surface. The area is undulated and as such is subjected to severe erosion.

(ii) *Shallow dark reddish brown to black clay loam.*—The colour variation of these soils is between 5 YR 3/2 (dark reddish brown) to 5YR 2/1 (black). They are mostly clayey loam occupying the elevated plains near Malegaon. Absence of lime on the surface of these soils is very characteristic, however the murum layer is mixed with some amount of lime in some areas—The type covers about 24% of the total cultivated area of the taluka.

(iii) *Medium dark reddish brown clay loam.*—The surface layer of this type of soil exibits a colour variation between 5 YR 3/2 (dark reddish brown) and 5 YR 2/2 (black) when dry. These soils are clay loam in texture and of angular blocky structure. Lime increases with depth of profile and occur in the lower layers either as nodules or may be finely mixed with coarse gravel and soil. Where the soils are completely eroded lime concretions are seen on the surface.

(iv) *Medium to deep dark grey clay.*—The colour variation is not much observed in this type of soil. The only variation is in depth and is dependent on topography. Lime is present in large amount on the surface and increases with depth. Soils being clayey the structure is mainly well formed angular blocky and though friable when moist, the soils are hard when dry. Deep cracks are often noticed on the surface.

Soils of Balegaon Taluka.—The area of 3,98,318 acres was traversed and in all 64 profiles were examined and sampled. The major area of the soils suffer from erosion (57—8 per cent.). The shallow soils cover more than 50 per cent of the total area of the taluka out of which half is light in texture consisting mainly of gravel and half is gravelly clay loam. Only about 12 per cent of the shallow soils are clay. Medium deep soils cover 40 per cent of the total area. Here also 1/3 of the type has gravelly clay loam to clay in texture. The proportion of deep clay soils is about 6 per cent the total areas. The areas under forest in the western and central part of the taluka are being brought under cultivation to distribute the lands to aborigines. These soils are rich clay loam to clay with medium depth.

Soils of Chandore Taluka.—The area of 2,36,761 acres was traversed and 56 profiles were examined. The major type of the soil in this taluka is of shallow nature. The texture varies from sandy loam to gravelly clay and at times clays also. This variation is mainly due to the topography and situation of the lands. Plain area with proper bunds are protected from erosion with the result that the texture is at times heavy. The other main types of soils are medium clay loam to clay covering equal areas.

Soils of Nandgaon Taluka.—This taluka covers a total of 2,69,328 acres geographical area. The soil is mostly shallow covering nearly 65 per cent of the cultivated area. However contrary to the soils of the adjoining Malegaon taluka 75 per cent. of the total area under cultivation has medium texture. The same four types of soils as in Malegaon taluka are met within the taluka. The following is the percentage of the four groups of soils met with in the taluka.

(1) Shallow clay loams	21%
(2) Shallow clay loams	44%
(3) Medium textured soils	30%
(4) Heavy deep soils	5%

The soils are permeable with good drainage and kharif crops are grown.

Soils of Yeola Taluka.—The area of 2,62,432 acres was traversed and in all 75 profiles were examined. As in Malegaon taluka there are mainly four types of soil namely (i) shallow clay loams; (ii) shallow sandy loam, (iii) medium clay loam, (iv) deep clay loams tending to clay and in addition a patch of deep clay soils is found towards Niphad side. Type (i) corresponds to type 2 of Malegaon taluka, contrary to the soils in Malegaon taluka, however the variation of lime is predominant factor in Yeola. This type of soil occupies about 30 per cent of the total area of the taluka and is mainly concentrated in the north east portion adjoining to Nandgaon boundary and is south-east round about Adsuregaon and Bharam.

Soils of Niphad Taluka.—The area of 2,60,015 acres was traversed and 42 profiles were examined. As the slope is gradual the soils are either clay loam or clays with varying depth. The main three types of soils met with are (i) shallow clay loams, (ii) medium clay loams and (iii) deep clay loams to clays.

In canal irrigated area water logged conditions have developed in deep soils with some patches of saline area. There is a difference in the colour of soils due to varying rainfall and erosion. In the north side the shallow soils are more reddish brown while on the southern sides the soils are dark grey to black in colour.

Soils of Sinnar taluka.—This taluka covers an area of 3,31,151 acres. In all 65 profiles were examined and samples collected. The main types are (i) shallow sandy loams, (ii) shallow clay loam, (iii) Medium clay loams, (iv) deep clay loams.

The shallow sandy soils cover about 37 per cent of the total area. The second type comes to 40 per cent. This is a major type of soil met within this area. Medium clay loams are scattered over the area and comprise of 14 per cent and 9 per cent respectiveiy of the total area.

(i) *Shallow light soil.*—There is no difference in colour while a slight variation in depth and amount of lime is observed.

(ii) *Shallow clay loams.*—These are dark reddish brown in colour with subangular blocky structure. Lime concretions are observed which increases with the depth. Unded this type, soils without lime are also met with.

(iii) *Medium clay loams.*—These soils are similar to the above except for the depth. Lime is present in large quantities in this type and it forms about 14 per cent of the total area.

(iv) *Deep clay loam.*—These are dark reddish brown soils with surface lime in large quantities and are of medium angular blocky structure. They are hard in dry condition with abundant lime concretion increasing with depth.

Soils of Hirakud Catchment Area

Detailed soil survey of thirteen villages in Bhedan watershed amounting to total area of 15,089 acres was completed. The revenue map 16"—1 mile was used and a profile was taken at every 100 acres.

In general the village land may be divided into three groups depending upon the relative position of the area.

(i) *Low lands.*—These are situated at the lowest level in the village and are generally located round about village tanks. They are deep, 5 to 6 ft. sandy loam to clay loam to clay in nature, very slidey and hard when dry. Water-level is generally high within 3 to 5ft. during summer.

(ii) *Up lands.*—These are situated generally on the upper side and the soils are generally coarse or fine sand to sandy. The lower layers are mostly sandy although the depth of the sandy layer may be at times more than 5 feet.

(iii) *Forest areas and gaucharans.*—The gaucharans are not bunded and they do not also grow any forest trees or grasses. As a result they are severely gullied. The gullies are deep and wide. The soils are generally sandy and soil depth varies widely according to the slope, on the lowest levels near nalas and seasonal streams the depth is generally higher.

Red and Laterite Soil Region 1—Calcutta

Reconnaissance soil survey of (I) 1,18,000 acres in Asansol subdivision, West Bengal, (II) 63,360 acres in Kharagpur Police Station in West Bengal, (III) 70,000 acres in Muruda Police Station in District Mayur Bhanj, Orissa and detailed soil survey of about 24,960 acres in Kanksa Police Station, Asansol sub-division in West Bengal have been completed and the soil maps have been prepared. The soil survey in Machkund river valley project is in progress and the area of 7,680 acres has been surveyed.

I. *Soils of the laterite soil areas of Asansol Sub-division in West Bengal.*—Soils of the high lands are laterites or lateritic and are formed from the underlying parent material. The progress of laterization is indicated by the formation of a pan of ferruginous concretions. In a high land, the depth of the soil is maximum at the top portion and is minimum at the edges, where rock exposures are common.

Soils of the lowlands have mostly been developed out of the materials carried downwards by rain water from the surrounding high lands. The soils by the sides of the rivers are alluvial and do not contain laterite within the depth of 5 feet, but may occur at a much lower depth, sometimes below 10 feet.

At places however, sub-soils are exposed due to erosion caused by flood water and that time has been converted into paddy lands. The soils by the sides of the rivers are alluvial and do not contain lateritic constituent below the surface.

The following soils have been identified and mapped on the basis of their profile characteristics. Their descriptions are given below:

Soils of lowlands. (1) *Pale brown lateritic.—Kuldiha series.*—This is found in Kanksa, Faridpur and Ondal Police Stations in the lowlands. The soils are very deep, and under cultivation growing mainly paddy. The top soil is sandy loam and has pale brown colour. Soils of highlands—

(1) *Reddish Yellow lateritic—Baidanga series.*—This series is found in Kanksa and Faridpur Police Stations. The soils are deep, moderately well drained and have forest cover. The surface is generally covered with dry and partly decomposed litter of thickness about 0:2 inches. Kaolinization is more prominent than laterisation. The texture of the top soil varies from loamy sand to sandy loam and the colour is reddish yellow.

(2) *Reddish Yellow murrum laterite—Bistupur series.*—This series occurs in Kanksa and Faridpur Police Station. The soils are moderately deep and moderately well drained. The surface layer is covered with dry and partly decomposed litter. The top soil has loamy sand to sandy loam texture. The murrum pan occurs below a depth of 42 inches.

(3) *Reddish Yellow murrum laterite—Kamalpur series.*—This series occurs only in Faridpur Police Station. The soils are moderately deep to deep, well drained soils. Due to action of river, round shapped quartz gravels have been deposited in this area. The top soil is reddish yellow in colour and loamy sand texture. The murrum layer mixed with gravel generally occurs at depth below 60 inches.

(4) *Reddish yellow murrum laterite—Vijoynagar series.*—This series is observed in Raniganj and Jamuria Police Stations. The soils are moderately deep to shallow and moderately well drained. The top soil has loamy texture and murrum pan generally occurs at 24 inches depth.

(5) *Yellowish red reddish yellow rock laterite—Sankarpur series and Chinchuria series.*—These two series occur in close association and it is very difficult to may them separately. The colour of the surface soil of yellow. So the above names have been given. The area having a particular soil series in major portion has been marked on the map to have that soil series.

(5a) *Yellowish Red and Reddish Yellow rock laterite—Sankarpur series.*—This series is found in Ondal and Ranigunj Police Station. These are coarse textured shallow soils. These soils also carry thin vegetation.

(5b) *Yellowish Red Reddish Yellow rock-laterice-Chinchuria series.*—This series is found in Faridpur, Ondal and Jumuria Police Stations. The soils are moderately deep to shallow. Occasional rock exposure is noted due to erosion. The soils generally carry thin vegetation.

II. *Soils of the laterite soil areas of Kharagpur Police Station in West Bengal.*—The soils of the highlands are laterite and lateritic and are formed from the parent material underneath. The progress of laterisation is indicated by the formation of pan of ferrugenous concretion at a lower depth. At top the soil depth is medium and it is minimum at the edges, where exposed rocks are common.

Soils of the lowlands have been developed from the materials carried by the rain water from the adjoining high lands. The soil is pretty deep. No ferruginous pan is found within 6′ soil depth, but they may occur at 10′—15′ depth.

The following soils have been identified.

The soils of the lowlands. 1. *Pale brown lateritic Kuldiha series.*—This is a common soil of the lowland under cultivation. This is similar to Kuldha series that are found in Kanksa and Faridpur Police Station in Asansol Sub-division.

2. *Light gray lateritic, Bisudha series.*—These soils are found in the very gently sloping cultivated uplands carrying terraced paddy cultivation. The top soil has sandy loam texture in most cases and has light grey colour.

Soils of highlands 1. *Reddish yellow murrum laterite, Bistupur series.*—This soil is moderately deep and moderately well-drained. This is similar to Bistpur series soils that are found in Kanksa and Faridpur Police Station.

2. *Yellow brown rock laterite, Khamsoli series.*—These are very shallow soils unsuitable for cultivation. The texture of the top soil is loamy sand. The murrum pan generally occurs at 11″ depth.

3. *Yellowish red-reddish yellow rock laterite Sankarpur series.*—These are coarse textured shallow soils and carry thin vegetation. These soils are similar to Sankarpur series that are found in Ondal and Raniganj Police Station in Asansol Sub-division.

III. *Soils of the laterite soil areas of Muruda Police Station in the District of Mayur Bhanj in Orissa.*—The highland soils are laterites and lateritic which are characterised by the formation of a ferruginous pan underneath. The depth of the soil over the murrum of laterite rock, varies from place to place due to erosion activities, but generally at the edges of a high land, the soils are very shallow.

Soils of the lowland are formed from the deposited materials, carried by rain water from the high lands and are quite deep. Number of ferruginous concretion increases with depth, but no iron pan is found even up to a depth of 15′. In the low land alluvial soil also occurs in some places.

Soils of the lowland (1) *Light grey murrum laterite, Raisol series.*—These are deep soils, poorly drained, formed on the deposits carried out by rain water from the adjoining high lands.

Soils of the highlands—(1) *Yellowish red rock laterite Bhaduasol series.*—These soils are shallow to moderately deep. The area is open

as well as covered with forest frequent exposures of laterite rock is also found. The physiography is gentle undulating and rolling. Medium to high sheet erosion is observed in the area.

(2) *Yellowish red murrum laterite, Benapati series.*—These are shallow soils formed in moderately sloping lands. High sheet erosion is prevalent in the area. The surface is covered with stingy grasses with occasional exposure of rock laterite.

(3) *Strong brown murrum laterite, Dhansol series*:—These are shallow soils formed in moderately sloping areas. High sheet erosion is prevalent. Forest cover with occasional exposure of laterite rocks are found.

(4) *Strong brown murrum laterite, Khuntia series*:—These are also moderately deep to deep and moderately well drained soils. The surface is covered with sal forest. Medium sheet and gully erosion is prevalent.

(5) *Yellowish brown murrum laterite, Itahari series*:—These are moderately deep to deep soils and are moderately well drained. The physiography is gently sloping. Medium sheet erosion is prevalent. The area is covered with dense Ial forest.

(6) *Yellowish brown murrum laterite, Damodarpur series*:—These are deep soils formed in uplands covered with forest, but are poorly drained.

(7) *Reddish yellow murrum laterite, Khanpur series*:—These are moderately drained deep soils formed in uplands covered with forest.

(8) *Reddish yellow murrum laterite, Kakband series*:—These are well drained very deep soil formed in uplands covered with forest.

IV. *Soils of Kanksa Police Station*:—The following soils have been identified and mapped in the area so far. Their descriptions are given below.

Light grey lateritic, Birudha series.—These soils are found in the very gently sloping cultivated uplands. Paddy is cultivated in the terraced fields. The area is moderately drained. These are similar to the Birudiha series soils of Kharagpur Police Station.

Pale brown alluvial, Kanksa series:—These soils are found in the lowlying alluvial fans. These are poorly drained soils and carry paddy cultivation.

V. *Soils of catchment area, Machkund river valley project*:—The soil conservation survey was started in the catchment area of the Kinchor nadi, one of the tributaries of the Machkund river. This area is in a state of progressive erosion and the hills are mostly bare. In the area surveyed so far, three categories of soils have been noted. The description of these soils are given below.

1. *Soils of the hill slopes*—(1) *Reddish brown lithosolic soils, Kalapada series*:—These soils are found in the dome shaped top of the hills and on the side of the hills, which are subject to high sheet erosion. The surface is gravelly and stony and has very little vegetation cover. These soils are unsuitable for cultivation and need afforestation.

2. *Soils of sloping uplands*—(1) *Yellowish red colluvial soil—Pipulput series*:—This area begins from the foot of a hill and extents upto the edge of the sloping uplands, dissected by the gullies and converted to paddy fields. The slope ranges from 3 to 8 per cent or more. The formation of these soils is due to process of colluviation by which deposition of eroded soil materials from the top hills, caused by run off, has taken place under the force of gravity. The surface of the land near the foot hills has stony phase. The depth of soil is shallow here and the lands may be cultivated with difficulty by practising proper soil conservation measures. At a distance from the edge of the hill, the soil is deep and friable and may rest on laterite rock. With appropriate soil conservation measures and good management, these soils are expected to produce good yield.

3. *Soils of the lowlands*—(1) *Dark reddish brown lowland soils, Kona series*:—These soils are in the water channels and gullies which were reclaimed by bunding and terracing for paddy cultivation. These areas lie between sloping uplands and are always in wet condition due to continuous seepage of water and are suitable for paddy cultivation.

Red and Laterite Soil Region II—Bangalore

1. *Survey of soils in Coorg*:—The work during the year was mainly directed towards the analysis of the various soil samples collected during the field survey, and also in preparing a tentative soil map of Coorg on the basis of differentiation into various soil series and associations. The area of about 1,00,000 acres has been surveyed and mapped.

Major series:—(1) Athur series. (2) Chothalli series. (3) Sidhapur series. (4) Ammathi series. (5) Bittangala series. (6) Napoklu series. The soils which may be grouped as associations would appear to fall under the following categories.

(1) Athur-Ammathi-Sidhpur association and (2) Sidhapur-Chethalli association.

Minor series:—(1) Arji. (2) Hoskottay. (3) Navkut. (4) Lakkund.

II. *Survey of soils in Andhra Pradesh*.—The detailed traverse survey of the Vayalpad taluk in Chittoor district and the adjoining Rayachoti taluk in Cuddappah district were completed during the year. The total area of 4,25,000 acres has been surveyed and mapped on 1″—1 mile maps. The soils in the area in general are shallow and sandy in texture. In localised places occurrence of considerable deposits of saline and calcareous materials have been noted and these have been demarcated in the maps. The occurrence of considerable quantities of lime stones in the form of dendritic formation may be due to the deposition of calcium carbonate dissolved out of the decomposition products of the basic rocks in the neighbouring hills and precipitation from the percolating waters in the sub-soil layers.

From the various profile pits and other natural cuttings studied, the soils in the Vayalpad taluk have been classified under four series for the non-calcareous type, which for convenience are designated as series I to IV and two calcareous types which are designated as series V and VI.

Soils series of Vayalpad—Non-calcareous types series I.—These are very shallow brown or reddish brown sandy loam, low in organic matter, structures less soils. The parent material "murram" is below 20 inches.

Series II.—These are brown to brownish red sandy loam, gritty, law in organic matter with reddish and yellowish murrum full of quartzite gravel as parent material at 3 feet depth.

Series III.—These are reddish brown sandy soil developed on the disintegrated coarse granite with quartzite gravel.

Series IV.—Red sandy soil with clay developed on granite.

Calcareous types—Series V.—Brown sandy, structureless soils developed on limestone with saline deposition.

Series VI.—Brown sandy well drained soils with the lime kankars at the bottom layer at the depth of 3 feet.

Soils of Raychoti Taluk.—During this survey 33 profile pits were excavated and the profile features in these and numerous other natural cuts were examined. It is found that the soils of this taluk can be classified under series which have already been described for Vayalpad, excepting that soils belonging to Vayalpad series VI do not seem to occur.

The soil map of this taluk is under preparation.

III. *Survey of soils in Mysore State.*—The total area of 1,25,000 acres in this state have been surveyed and mapped.

Honnali Taluk.—The area is mainly covered over by shallow red soils of a coarse textile, which are distinguished by the presence of a continuous stone-line formed of quartz gravel, at the interface between the B and C horizons. This stone line exists at a depth varying from a few inches from the surface to about 18″ or 20″ from the surface and appears to represent the remnant of a previous erosion era. In most of the areas, the granitic parent rock of the soils appears as thin layer with the more basic schist and dolemite intrusions, where they have not cut through the surface, appearing at only a short depth from the surface.

The red soils have been described under three series namely (i) the Honnali series, (2) the Kundur series and (3) the Chikkagonigere series, of which the first two are non-calcareous and the third one calcareous. The calcareous soils are found in localised places at the foot of the schist ranges and are very likely formed by the movement of lime and other bases dissolved from the nearby basic rocks, and their deposition in the sub-surface layers. The black soils which appear to be of variable depth are not differentiated and are described under one series only.

Shikarpur Taluk.—The soils of this taluk are found to fall under only two series, of which the first, named the Shikarpur series occurs extensively over the taluk, while the second the Malur series in a limited area.

A characteristic of the Shikarpur series soils is occurrence of a deep layer in the B horizon, which ranges in thickness from a few inches to nearly two feet and over, of rounded iron concretions. The occurrence of beds of these pisolitic iron concretions overlying soft, decomposed

but undistributed schistose materials lead to infer that these are not related or developed from the underlying material and are transported and deposited.

Sorab Taluk.—A rapid reconnaissance soil survey was conducted in this taluk and about 30 profile pits were examined. The soils have been classified into three series namely (1) Chegatur series, (2) Tekken series and (3) Hale Sorab series.

Survey of soils in Kerala.—A rapid reconnaissance of South and Central Kerala was carried out by the Soil Correlator in company with the Agricultural Chemist of Kerala, with a view to fix the localities where soil survey could be begun on a priority basis.

CARTOGRAPHIC LABORATORY

General

The building of the Cartographic Laboratory is being fitted up with 60 kw three phase power supply and it is expected that soon the photo-litho camera and the colour press will be fitted up and processing and printing of soil maps prepared by the field parties of the Integrated Scheme of All India Soil and Land Use Survey will be taken up.

Installation of the equipment.—The proof press and the contact printer have been assembled and have been brought into working order.

Administration of the Cartographic Service.—An outline of procedure has been laid down for the cartographic service from the pre-field stage to the final reproduction stage. According to this, jobs have been distributed to the cartographic laboratory and regional cartographic section according to the equipment facilities and requirements of the work as also the qualifications of the staff.

Preparation of Basic Soil Region Maps

It has been widely felt that topography plays an important part in the soil formation. A widely accepted method of depicting topography for soil formation in terms of slopes percentages is applied to India. The slope categories are 1·2 percent, 2·4 percent, 3·6 percent, 4·8 percent, 6·0 percent and 7·2 percent. The areas taken for detailed examination of slope analysis were Madras and Mysore states.

Training.—Twentyseven Soil Survey Assistants were given five week's intensive training in soil survey at Dehra Dun and then sent to their respective working centres.

A tentative manual for detailed standard soil survey was drawn up for immediate use of the field workers of the staff. This manual has also been circulated to the State Governments for comments and suggestions for revising it.

PROGRAMME OF WORK OF THE INTEGRATED SCHEME OF ALL INDIA SOIL AND LAND USE SURVEY FOR 1958-59.

(1) *Alluvial Soil Region, Delhi* :

Detailed soil survey (16″—1 mile) and reconnaissance soil survey (1″—1 mile will be carried out as below :

(*i*) Survey of Bhakra-Nangal catchment :

Detailed soil survey of	2,50,000 acres.
Reconnaissance soil survey of	7,50,000 acres.

(*ii*) Survey of Chambal catchment :

Detailed soil survey of	1,50,000 acres.
Reconnaissance soil survey of	4,50,000 acres.

(*iii*) Soil survey of Bhakra Nangal (Command area) Jullundar and Hoshiarpur Distts.

Detailed soil survey of	2,000,000 acres.
Reconnaissance soil survey of	50,000 acres.

(*iv*) Soil survey of irrigated areas of Rajasthan :

Detailed soil survey of	1,20,000 acres.
Reconnaissance soil survey of	2,20,000 acres.

(2) *Black Soil Region, Nagpur* :

Detailed soil survey (16″—1 mile) will be carried out as below :

(*i*) Survey of Sapairiaver watershed in Sundargarh Dist. (Orissa) under Hirakud catchment . . . . . 1,00,000 acres.

(*ii*) Survey of Bhavan Thelia and Hathia watersheds, Hirakud catchment area . . . . . 1,35,000 acres.

(*iii*) Survey of afforestation and anti-erosion works in dry eroded land in Maratha Wada area (Bombay State) . . . 75,000 acres.

(*iv*) (*a*) Survey of Kurnool Distt. (Mysore State) . . . 75,000 acres.

(*b*) Survey of area in the scheme "contour bunding" (Hyderabad-Karnatak and Bombay-Karnatak) . . . . . 75,000 acres.

(*c*) Survey of area in the scheme "Introduction of dry farming in bunded areas" . . . . . 75,000 acres.

(*v*) Survey of area in the scheme "Bhopal land development" . 75,000 acres.

(*vi*) Survey of area in the scheme"soil conservation expansion of area under cultivation and mass bunding schemes (M.P.)

(*vii*) Survey of area in the scheme "Construction of field embankment : (M.P.) . . . . . 75,000 acres.

(3) *Red and Laterite Soil Region*—1*Kharagpur* (*at present Calcutta*): (*Calcutta*):

Detailed soil survey (16″—1 mile) will be carried out as below :

(*i*) Detailed soil survey of catchment area of Machkund river (Orissa) . . . . . 1,44,000 acres.

(*ii*) Detailed Soil survey of the catchment area of Machkund river (Andhra Pradesh) . . . . . 1,44,000 acres

(*iii*) Detailed soil survey of the catchment area of Kosi river (Nepal) . . . . . 57,600 acres.

(*iv*) Detailed soil survey of irrigated areas of the Distt. of Burdwan in West Bengal commanded by D.V.C. Project . . . . . 66,800 acres.

(*v*) Detailed soil survey of irrigated areas of the distt. of Puri in West Bengal commanded by Naraj Delta Project . . . . . 28,800 acres.

(*vi*) Detailed soil survey of irrigated area of the distt. of Cuttack in Orissa commanded by Naraj Delta Project . . . . . 28,800 acres.

(4) *Red and Laterite Soil Region—II (Bangalore)*:

Reconnaissance soil survey (1″—1 mile) will be carried out as below:

(*i*) Reconnaissance soil survey of Honnali, Shikarpur and Sorab taluks (Mysore) . . . . . 1,00,000 acres.

(*ii*) Reconnaissance soil survey Sagar and Hosnagar taluks (Mysore) . . . . . 1,00,000 acres.

(*iii*) Reconnaissance soil survey Rayachoti, Chandragiri, Razampet and Nalagoda taluks (Andhra Pradesh) . . 1,00,000 acres.

(*iv*) Reconnaissance soil survey of Shertalai, Tiruvala, Ambalpuzha, Kottayam taluks (Kerala) . . . . 1,00,000 acres.

(*v*) Reconnaissance soil survey of Coorg, Pondicherry, Palni, Periakulam, Tirumangalam taluks (Madras) . . 1,00,000 acres.

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Agricultural Engineering

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2. Menon, M. G. R. and Das, J. N. (1958). Taxonomic studies on Indian *Membracidae*.
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Horticulture

1. Kahlon, A. S. and Randhawa, G. S. (1957). Integration in cold storage industry.
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2. Krishnamurthi, S. and Bhandari, P. B. (1957). Modification of leaves in chilli (*Capsicum frutescens* L.) as a result of whole plant sprays of high concentration of certain plant regulators (Plant hormones).
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5. Randhawa, G. S., Singh, J. P. and Malik, R. S. (1958). Fruit spliting in some fruit trees with special reference to lemon (*Citrus limon*).
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6. Randhawa, G. S., Singh, J. P. and Seshadri, V. S. (1958). A promising bud mutation in Foster Pink grape fruit.
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9. Singh, J. P. (1957). The effect of some new growth regulating compounds on growth of Coleus and tomato seedlings.
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Mycology and Plant Pathology

1. Chona, B. L. (1956). Controlling plant diseases: Sugarcane smut.
Indian Fmg., **6**(9): 27—33.

2. Chona, B. L. (1958). Some diseases of sugarcane reported from India in recent years.
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Indian Phytopath., **11**: 130—32.

8. Joshi, L. M. and Kak, D. (1958). Certain morphological peculiarities in races 34 and 75 of black rust of wheat.
Indian Phytopath., **11**: 194—96.

9. Joshi, L. M. and Reddy, A. R. (1958). Taxonomic studies of the rust *Uromyces indigoferae* Deit. and Holw.
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10. Sreekantiah, K. S. and Joshi, L. M. (1958). *A Trichothecium* sp. (*Cephalothecium* sp.) hyper-parasite on black rust of wheat. *Indian Phytopath.*, **11**: 63—65.

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V. STUDENTS, RESEARCH FELLOWS AND HONORARY RESEARCH WORKERS.

(a) *Students awarded the Diploma of Associateship of the Indian Agricultural Research Institute.*

Name	Title of Thesis
Division of Agronomy	
1. Barewar, R. G. . . .	A study of the agricultural development in relation to the effectiveness of extension methods in Nangloi area.
2. Bholey, D. K. A. . . .	Most effective combination of extension methods to make the fertilization programme for wheat crop successful.
3. Bisen, C. R.	Study of the optimum time of application of varlous nitrogenous fertilizers to wheat (N. P. 718).
4. Chatterjee, B. K. . . .	Effect of placement and split application of various nitrogenous fertilizers on the yield and other agronomic characters of rice (*Oryza sativa* L.).
5. Datey, J. B.	A study of extension methods influencing the introduction and saturation of improved seeds in intensive cultivation blocks.
6. Deshmukh, T. M. . . .	Effect of different rates of 2, 4-DB on wheat population in wheat crop (*Triticum vulgare*).
7 Deshmukh, V. S. . . .	Relative study of the demonstration techniques towards introducing seeds, fertilizers, and implements in the intensive cultivation projects.
8. Devappa, K.	Effect of time of planting on the performance of some *Boro* (spring) varieties of rice (*Oryza sativa* L.).
9. Dhimole, O. P. . . .	Influence of various levels of nitrogen and phosphate on three varieties of peas under rainfed conditions.
10. Gupta, O. P.	Effects of different formulations of weedicides on weeds in sugarcane.
11. Jawada, P. M. . . .	Differential responses to various modes of phosphate placement in wheat.
12. Jethmalani, S. C. . . .	Effect of organic and inorganic manures on soil fertility in relation to wheat.
13 Jhala, B. M.	Performance of Blue Panic and Rhodes grass in relation to frequency of cutting and fertilizer treatments.
14. Misra, M. K.	Optimum seed rate, spacing and date of sowing of N.P. 710 and N.P. 718 varieties of wheat.
15. Misra, R. S.	Progress of agricultural improvement by various extension techniques amongst different categories of farmers in extension projects.

Name	Title of Thesis
16. Mudholkar, N. J.	Optimum time of application of three sources of nitrogenous fertilizers on wheat.
17. Parashar, C. R. K.	Response to organic manures and inorganic fertilizers on wheat in cereal and legume rotations.
18. Ramiah, V.	Weed control in potato by chemical and cultural methods.
19. Rawal, R. T.	Interrelation of irrigation, nitrogen and sowing dates on cotton.
20. Saha, A. K.	Effect of variation in depth of cultivation, fertilizel levels and method of application on potato.
21. Sahay, K. N.	Response of linseed varieties to levels of nitrogen and phosphorus and mode of application.
22. Sengupta, A. K.	Varietal response to nitrogen in sugarcane.
23. Shanware, P. G.	Study of the effect of irrigation, nitrogen and seed rate in sugarcane.
24. Sharma, S. K.	A study of effects of villagers' participation in rurar development ; its limitations and suggestions for improvement.
25. Sethi, M. L.	Investigations on the extension methods already employed to intensify the use of manures and fertilizers; their limitation and suggested lines of improvement.
26. Sikka, H. C.	Agronomic studies on relative merits of various crop rotations.
27. Singh, Jagdish	A study of the agricultural extension methods in relation to achievements and the limitations towards agricultural development in the Nangloi extension area.
	Division of Botany
1. Ahluwalia, B. S.	Study of genetic diversity in relation to specific combining ability of inbred lines of maize (*Zea mays* L.)
2. Bhattacharya, R. K.	Genetics of rice: Inheritance of anthocyanin pigmentation and other morphological characters in intervarietal crosses within *indica* group.
3. Chopra, V. L.	A. Induction of pollen sterility in some crop plants. B. Induction of polyploidy in water melon and musk melon.
4. Dabral, K. C.	A comparative study of drought resistance of some *durum* and *vulgare* wheats.
5. Dave, H. R.	Inheritance of rust resistance and other characters.
6. Dey, B. B.	Studies on techniques for rapid determination of viability and germinating capacity of crop seeds.
7. Hooroo, L. S.	Heterosis : its utilisation in vegetable breeding with special reference to tomato (*Lycopersicon esculentum* Mill.)

Name	Title of Thesis
8. Jha, K. K.	Monosomic analysis of some characters in wheat.
9. Karibasappa, B. K. . . .	Cytogenetical studies in the genus *Oryza* : the cytology of two diploid and three tetraploid wild species, and of chromosome variants.
10. Majumdar, P. K. . . .	Use of ionising radiation in the improvement of ornamental plants.
11. Mehta, N. P.	Study of comparative performance of red and amber-grained selections of wheat under rainfed conditions at Delhi.
12. Pathak, S. G.	Studies on hybrid vigour in inter-varietal crosses of *Gossypium hirsutum*.
13. Qureshi, M. R. H. . . .	Study of varietal differences in *Gossypium hirustum* L. with regard to neppiness and factors contributing to nep formation.
14. Rao, P. H.	Varietal reaction of wheat to conditions of deficient soil moisture.
15. Sankaranarayanan, K. . .	Studies of the effects of antibiotics and other chemicals on the growth of excised embryos in artificial media.
16. Sharma, J. N.	Induction of polyploidy in some ornamental plants.
17. Subramanyan, K. N. . .	A. Studies on the tetraploid of berseem and *Senji* with reference to their cytological behaviour and seed setting.
	B. Cytogenetical studies in some economic grasses.
18. Tiwari, N. P.	Study of *japonica-indica* hybrids of rice under normal and high levels of soil fertility and the possibilities of breeding strains suitable for the two levels.
19. Venkataswamy, T. . . .	Genetical and cytogenetical studies of sterility in inter-racial hybrids of rice (*Oryza sativa*).
20. Wanjari, M. R. . . .	A study of heritability and of genetic correlation between characters contributing to yield in linseed.

Division of Soil Science and Agricultural Chemistry

1. Ali, M. A.	Genesis of saline and alkaline soils in the aluvial tracts of arid and semi-arid regions (Western U.P.).
2. Anantharaman, P. V. . .	Study on the fertility status of some acid soils.
3. Behera, B.	Effect of gypsum on decomposition of organic matter and nitrogen transformation in soils.
4. Bisen, D. C.	Foliar diagnosis studies and relative efficiency of dicalcium phosphate and single superphosphate on wheat.
5. Deoras, C. M.	Comparative study of black soil and associated soils in semi-humid regions.
6. Dewan, H. C. . . .	Physical and chemical studies of virgin and cultivated land at Nabha.

Name	Title of Thesis
7. Godase, N. G.	Formation of different soils on the basalt rock under varying conditions of rainfall in Bombay State.
8. Goswami, N. N.	Effect of moisture and organic matter levels on phosphorus availability and up-take by wheat/paddy on typical soils.
9. Gupta, V. K.	Studies on the genesis of alluvial soils of semi-arid and semi-humid tracts.
10. Haria, N. H.	Fluctuations in the nutrient availability of soils with depth, seasons and stages of crop growth.
11. Misra, C. P.	The role of clay-humus complexes in the fertility of some Indian soils.
12. Mittal, O. P.	Study of micro-element status of some typical Indian soils.
13. Mutatkar, V. K.	Carbon-nitrogen status of soils of arid and semi-arid regions.
14. Prasad, K. K.	Physical, chemical and mineralogical studies of representative black soil profiles formed on trap rock.
15. Rao, Y. N.	Comparative study of laterites and associated soils.
16. Ravi Kumar, V.	Genesis of alluvial soils in the arid and semi-arid regions.
17. Sarma, V. A. K.	Studies on the physico-chemical properties of some Indian soils with special reference to the red and lateritic soils.
18. Shankar, K.	Study of the efficient utilization of some new nitrogenous fertilizers.
19. Shinde, J. E.	Phosphorus fixation and availability in some typical soils—effect of organic matter, silicates and chelating agents.
20. Singh, D. K.	The nutritive value of pulse protein supplemented with amino acids and vitamin B12.
21. Singh, H.	Experiments in terpenes and the study of the rate of the dehydrochlorination of chlorinated compounds.
22. Srivastava, L. L.	Processing and availability of bone and indigenous rock phosphate fertiliser products.
	Division of Entomology
1. Bera, B. K.	Tolerance in *Apanteles angleti* Mueseback to various temperatures and humidities.
2. Das, J. N.	Studies on some Indian Membracidae (Hemiptera).
3. Joshi, S. A.	Resistance to some of the insecticides by beneficial insects (parasites and honey bees).
4. Kathuria, D. S.	Effect of temperature and humidity on the rate of development of *Bracon gelechiae* Ashmead.

Name	Title of Thesis
5. Kumar, S. S.	Effect of temperature and host density on the rate of increase of population of *Bracon gelechiae* Ashmead.
6. Mansingh, A.	Relative resistance of different stages of desert locust, *Schistocerca gregaria*, to insecticidal injections.
7. Narayanan	Efficacy of insecticidal films on the control of just-hatched larvae of internal feeders.
8. Nigam, M. P. . . .	Effect of temperature on the uptake and elimination of HCN fumigant by insects.
9. Pawar, J. G.	Studies on some Indian Aphididae (Hemiptera).
10. Sharma S. K.	Fumigation of some stored product pests.
Division of Mycology and Plant Pathology	
1. Dhanraj, K. S. . . .	Sector formation in *C. falcatum* and detailed studies of individual variants.
2. Pingaley, K. V. . . .	Study of mosaic of soyabean.
3. Rajagopalan, K. . . .	Bacterial leaf spot of chilli.
4. Reddy, A. R.	Studies on *Indigofera* rust.
5. Sahani, M. L. . . .	Studies on sugarcane rust in India.
6. Sastry, K. S. M. . . .	Virus-vector relationship of chilli mosaic virus.
7. Sushil Kumar	Physiological studies of *Lophotrichus ampulus* Benj.
8. Singh, Pritam	Further studies on the biological activity of the antibiotic substance of *Bacillus subtilis* in soil and plants.
9. Tiwari, M. M.	Studies on nature of red rot resistance: Infection histology of resistant and susceptible cane varieties.

(b) *Students admitted to the post-graduate course:*

Division of Agronomy

1. Ankamma, C.
2. Banerjee, S.
3. Basappa, K. S.
4. Deshpande, M. L.
5. Dhoble, T. L.
6. Idhale, B. B.
7. Jain, K. L.
8. Jain, M. L.
9. Kar, L. N.
10. Khadgi, P. P.
11. Kherde, R. L.
12. Lodha, G. C.
13. Lokhande, M. R.
14. Mahesare, V. L.
15. Mahapatra, S.
16. Mukhopadhyaya, S. K.
17. Neog, A. K.
18. Negi, G. S.
19. Prasad, C. S.
20. Prasad, S. N.
21. Raoot, M. G.
22. Reddy, S. N.
23. Roy, S. K.
24. Sinha, K. P.
25. Sinha, R. C.
26. Shah, K. M.
27. Singh, N. B.
28. Tikke, L. G.
29. Thakar, K. D.

Division of Botany

1. Appa Rao, P.
2. Bansal, R. K.
3. Batcha, M. B. G. R.
4. Bhatia, C.
5. Bhatt, G. M.
6. Chawda, D. H.
7. Chaugule, D. S.
8. Dawson, M. J.
9. Gupta, A. C.
10. Gopalkrishna, R.
11. Iyer, K. N.
12. Kurup, A.E.S.
13. Prasad, R. B.
14. Rana, R. S.
15. Rao, S. B. P.
16. Ray, M.
17. Sahay, B. N.
18. Satpathy, D.
19. Sharda, R. P.
20. Upadhya, M. D.

Division of Entomology

1. Chatterji, P. B.
2. Desai, M. J.
3. Das, L. K.
4. Jalal-ud-Din.
5. Kalode, M. B.
6. Khan, M. S. H.
7. Pramanik, L. M.
8. Sri Ram.
9. Sharma, H.C.
10. Pritam Singh.
11. Gurusharan Singh.
12. Saini, M. L.

Division of Horticulture

1. Bhattacharya, S.
2. Biswas, G. S.
3. Deo, P. V.
4. Dhuria, H. S.
5. George, P. V.
6. Nair, P. C. S.
7. Nair, P. K. R.
8. Pathak, S. C.

Division of Mycology and Plant Pathology

1. Deshpande, B. G.
2. Goel, L. B.
3. Krishna Rao, P.
4. Kandaswamy, T. K.
5. Padhi, B. M.
6. Sita Rama Prabhu, A.
7. Sethi, K. K.
8. Sreenivasan, T. N.

Division of Soil Science and Agricultural Chemistry

1. Abrol, I. P.
2. Anjaneyalu, B. S. R.
3. Banerjee, S. P.
4. Gautam Dev.
5. Gupta, K. G.
6. Gowda, B. S. P.
7. Kolarkar, A. S.
8. Lala, S. C.
9. Mathur, B. S.
10. Mathur, S. P.
11. Narayana, M. R.
12. Parthasarathi, K.
13. Patel, M. M.
14. Patel, S. P.
15. Prasad, R.
16. Raut, T. B.
17. Rosha, N. S.
18. Sahu, D. K.
19. Subramanian, T. R.

(c) *Students admitted to short courses of training*:

(i) Three months' course on Use of Radio-isotopes in Agriculture

1. Bapat, M. V.
2. Chakravarti, A. S.
3. Dahiphale, M. V.
4. De, R. (Dr.)
5. Gupta, Y. P.
6. Koshi, M. M.
7. Natarajan, C. P.
8. Rattan Lal (Dr.)
9. Sawhaney, P. C. (Dr.)
10. Tripathi, R. D.
11. Ved Prakash.

(ii) One-Year Plant Protection Course

1. Chaturvedi, K. B.
2. Purohit, S. P.
3. Singh, S. P.
4. Timande, B. M.

(iii) Vigyan Mandir Scheme

1. Agnihotri, B. N.
2. Sahai, M. M.
3. Sharma, B. K.
4. Velankar, S. R.
5. Venkatachalam, C. V.
6. Venugopalan.
7. Verma, S. B.

(d) *Research Fellows*:

Division of Agronomy

1. Yadav, Y. S.
2. Puri, D. N. (Ministry of Scientific Research).

Division of Botany

1. Bhaskaran, S. (I.C.A.R.)
2. Joginder Nath.

Division of Entomology

1. Chawla, S. S.

Division of Soil Science and Agricultural Chemistry

1. Goswami, N. N.
2. Grewal, J. S.
3. Mistry, K. B. (Ministry of S.R.)
4. Paliwal, K. V.
5. Rama Rao, M. V. (I.C.A.R.).
6. Shakuntala (Miss).
7. Singh, Manmohan.

Division of Mycology and Plant Pathology

1. Manocha, M. M. (I.C.A.R.)
2. Reddy, A. R. (I.A.R.I.).
3. Shastry, K. S. M. (I.C.A.R.)
4. Shrivastava, K. C. (I.A.R.I.)

(e) *Honorary Research Workers*:

Division of Botany

1. Patel, K. P.

Division of Soil Science and Agricultural Chemistry

1. Folster, H.
2. Ramakrishna, P.
3. Sadaphal, M. N.
4. Paliwal, K. V.

Division of Mycology and Plant Pathology

1. Sastry, K. S. M.

(f) *Other students who received training in different Divisions from time to time:*

1. Badigar, V. V.
2. Prasad, B. G.
3. Anand, S. C.
4. Grewal, G. S.
5. Shankukha Rao, N. (Dr.)
6. Prasada Rao, T. D.
7. Murthy, H. P. S.

VI. ABSTRACTS OF THESES SUBMITTED BY THE POST-GRADUATE STUDENTS (1957)

Division of Agronomy

1. Barewar, R. G. *A study of the agricultural development in relation to effectiveness of extension methods in Nangloi area*

While investigating the extent to which the farmers have adopted the improved farm practices, it was observed that the percentage of area saturated with wheat N.P. 718, barley N.P. 13, oats N.P. 1, gram N.P. 58, *bajra* T. 55 and sugarcane *C.O.* 647 were 45·2, 75·7, 72·4, 42·7, 40·6 and 16·6 respectively. The percentage of farmers adopting use of ammonium sulphate, green manuring, victory plough, olpad thresher, seed-drill and *bajra* weeder were 75, 45, 53, 39, 13 and 12 respectively. The percentage of adoption of these practices was high with bigger size holding cultivators while small size holding farmers adopted more practices.

2. Bholey, D. K. A. *Most effective combination of extension methods to make the fertilisation programme for wheat crop successful*

The study was conducted in 15 villages of Delhi territory to investigate the most effective combination of result demonstration, individual contact, group and mass contact to popularise the fertiliser programme.

The result demonstration was most convincing but was least efficient from the aspect of cost. Individual contact methods were powerful in influencing but were costly and time consuming. The mass contact methods were least appealing to the mass while the group contact methods were moderate in appeal and efficiency per unit cost. The most adjustable combination for the present day needs appeared to be lecture meeting with direct approach which gave a good effectiveness as well as efficiency index.

3. Bisen, C. R. *Study of the optimum time of application of various nitrogenous fertilisers to wheat (N.P. 718)*

Ammonium sulphate, ammonium nitrate, chilean nitrate and urea proved equally effective as nitrogenous fertilisers, at 20 and 40 lb. N. acre. Chilean nitrate and ammonium nitrate showed differential response to time of application. In case of both the fertilisers late application of fertilisers, *i.e.*, at 8 weeks after sowing or split application of half at sowing and the remaining half 4 or 8 weeks after sowing gave better response than application at sowing. Ammonium sulphate and urea gave some response to various times of application.

4. Chatterjee, B. K. *Effect of placement and split application of various nitrogenous fertilisers on the yield and other agronomic characters of rice (Oryza sativa L)*

At Central Rice Research Institute, Cuttack, ammonium sulphate, ammonium chloride, urea and ammonium phosphate were compared at 30 lb. N/acre in relation to different methods and time of application.

Ammonium sulphate, ammonium chloride and ammonium phosphate proved equally effective while urea was least efficient. No differential behaviour of fertilisers to method and time of application was observed. In general, placement of fertilisers gave more yield than surface broadcast. In main season, split application in two equal doses, one at planting and other before flowering gave highest yield while in the second season application of fertilisers in pellets three weeks after planting appeared to be most effective.

5. Datey, J. B. *A study of extension methods, influencing the introduction and saturation of improved seeds in intensive cultivation blocks.*

Out of the 19 villages, 8 villages were selected for the study on the basis of degree of saturation of improved seeds, such as (1) villages saturated above 50 per cent in area and (2) villages saturated below 50 per cent in area. The highest degree of saturation was of wheat—followed by gram. *Bajra* occupied the third position. Cultivators with more than 25 acres of holding had more area under improved seed. Result demonstrations and the combination of result demonstration and neighbour's influence proved most effective.

6. Deshmukh, T. M. *Effect of different rates of application of 2, 4—DB on weed population in wheat*

2, 4-DB applied at the rate of 8 and 16 ozs. acid equivalent per acre showed significant reduction in weed population over control, the reduction being 50·4 and 67·5 per cent respectively. Dicots showed greater susceptibility than monocots. The combination of application of 2, 4-DB at 8 oz acid equivalent/acre and ammonium sulphate at 30 lb. N/acre in 100 gallons of water as post-emergence spray at about 45 days after sowing gave complete control of broad-leaved weeds with substantial increase in grain yield.

7. Deshmukh, V. S. *Relative study into the demonstration techniques towards introducing seeds, fertilisers and implements in the intensive cultivation project*

The effectiveness of demonstration programme was less pronounced as this was not undertaken with the participation of local leaders. The result and method demonstrations proved more effective in remote villages, while the indirect influence and personal contact were more fruitful in progressive villages.

8. Devappa, K. *Effect of time of planting on the performance of some boro (spring) varieties of rice (Oryza sativa L)*

During investigations conducted at the Central Rice Research Institute, Cuttack, it was found that December plantings gave uneven stand and poor growth which resulted in less yield. The yields of grain and straw increased with advancement of planting dates. The maximum grain yield was recorded from the planting taken during 2nd week of February. P.T.B. 10 and Topa 1 proved more suitable for late plantings while M.T.U. 15 gave best results with early planting.

9. Dhumole, O. P. *Influence of various levels of N and phosphate on three varieties of peas under rainfed conditions*

Differential response of N.P. 29, early Badger and Bonneville was studied to different levels of N and P_2O_5. Amongst these varieties Bonneville gave best yields followed by N.P. 29 and early Badger. Doses of N (10, 20 and 30 lb N/acre) gave no crop response, while 60 lb P_2O_5 acre proved more effective than 30 lb dose in increasing crop yield. Bonneville responded best to doses of P_2O_5 followed by N.P. 29 and early Badger.

10. Gupta, O. P. *Effects of different formulations of weedicides on weeds in sugarcane*

Four formulations of weedicides, *viz.* sodium salt of 2, 4-D, caster 2, 4-D, amine 2, 4-D and sodium MCPA were compared at 8, 16 and 32 oz. of acid equivalent/acre. These weedicides were sprayed two months after planting of sugarcane. For mutgrass (*Cyprus rotundus*) sodium MCPA and amine 2, 4-D proved highly superior, while for Barnyard grass (*Echinochloa colonum*) caster 2, 4-D was significantly superior. For dicot weeds no such differential response was noted. Higher rates of application gave better control of weeds except Bermuda grass (*Cynodon dactylon*), *Triantbeam monogyna* and *Portulaca sp.* remained unaffected by any of these treatments. Economically, application of 8 oz. of sodium salt of 2, 4-D/acre proved the best.

11. Jawade, P. M. *Differential response to various placements of phosphate on wheat*

Placing of phosphate fertilisers either super phosphate or ammonium phosphate in bands and 2½ inches below seed gave better response than broadcast. Superphosphate and ammonium phosphate proved equally effective. The dose of 40 lb/P_2O_5/acre gave significantly higher yield over the control.

12. Jethamaboni, S. C. *Effect of organic and inorganic manures on soil fertility in relation to wheat*

Among the organic manures green manuring and castor cake proved superior to farmyard manure. Among the inorganic fertilisers application of N, N+P, and NP+K increased wheat yield than P only. Green manuring and castor cake had no effect on yield when applied in combination of inorganic manures. Combination of F.Y.M. with N, N+P and N+P+K, however, gave better response.

Application of 20 lb N in various forms increased wheat yield by 2·9 md./acre. Green manuring was found to be more economical.

13. Jhala, B. M. *Performance of blue panic and rhodes grass in relation to frequency of cutting and fertiliser application*

Effect of 40, 80 and 100 lbs. N/acre was studied on the fodder yield of blue panic (*Panicum antidotale*) and rhodes grass (*Chloris gyana*) in relation to frequency of cutting (20, 30 and 40 days interval). Green fodder yield of both the grasses increased with the higher doses of N. The late clippings produced slightly higher yields. However, the protein content was low compared to frequently clipped fodder.

14. Misra, M. K. *Optimum seed-rate, spacing and date of sowing in N.P. 710 and N.P. 718 varieties of wheat*

The response to 3 levels of seed-rate, 8 spacings and 3 dates of sowing were studied under field conditions for N.P. 710 and N.P. 718 wheat varieties. It was found that seed-rate and spacing showed no interaction response in case of grain yield. However, N.P. 718 gave significantly higher yield than N.P. 710. The optimum combinations of seed rate and spacing proved to be 70 lb. seed-rate, and 12 inches spacing. Regarding the effect of date of sowing, November and December sowing resulted in poor yield as compared to the first sowing. There was a progressive decline in yield in delaying the time of sowing.

15. Misra, R. S. *Progress of agriculture improvement by various extension techniques amongst different categories of farmers in extension project*

The study made in two villages in the intensive cultivation project showed great disparity in the size of holding and the progress achieved by the cultivators belonging to different size of holding classes. The cultivators belonging to farm holding of 10-20 acres were definitely superior in the adoption of improved farm practices. It was also observed that the cultivators having subsistance holdings had greater incentive to adopt the new practices.

16. Mudholkar, N. J. *Outimum time of application of three sources of nitrogenous fertilisers to wheat*

Ammonium nitrate proved slightly superior in increasing wheat yield to ammonium sulphate and urea, with their relative rating as 108·9, 100 and 96·3 respectively. Urea produced more straw than ammonium sulphate while reverse was the case for grain production. On an average, application of 20 lb. N/acre increased total produce, grain and straw yield by 26·9, 25·3 and 27·1 per cent respectively. Application of N fertilisers at the time of first irrigation gave higher yield than application at sowing.

17. Parashar, C. R. K. *Response to organic manures and introganic fertilisers to wheat in cereal and legume rotation.*

Response to application of inorganic fertiliser and residual effect of F.Y.M. and castor cake was studied in the legume rotation (wheat-maize-peas-maize) and cereal rotation (wheat-maize-wheat-maize). The response was better under the legume rotation. Application of 30 lb N+50 lb P O or 30 lb N+50 lb. P O+50 lb. K O gave better response compared to organic manures. The highest net profit of Rs. 187 was obtained with the application of N+60 compared to Rs. 164·4, Rs. 80·45 and Rs. 65·51 with N+P+K, castor cake and F.Y.M. respectively.

18. Ramaiah, V. *Weed control in potato by chemical and cultural methods.*

2, 4-D and M.C.P.A. applied at the rate of 6 or 12 ozs acid equivalent/acre controlled most of the *rabi* weeds. On an average application of 6 and 12 oz. of weedicides killed 65 and 84 per cent of weeds respectively. Earthing up immediately after planting showed a significant reduction in weed population compared to earthing done 6 weeks after planting. Application of weedicides at lower does gave higher yields of potatoes compared to control plots while higher rates gave lower yields.

19. Raval, R. T. *Inter-relationship of N and sowing dates on cotton.*

The inter-relationship was worked out amongst date of irrigation (light, medium and heavy), doses of N (20, 40 and 80 lb. N/acre) and three sowing dates (20 days' interval with first sowing on 2nd May). All three main factors increased significantly crop yield, however, response to irrigation was rather small. Effect of doses of N was more pronounced in the first date of sowing while in the third sowing the effect was negligible

20. Soha, A. K. *Effect of variation in depth of cultivation, fertiliser levels and methods of application on potato*

The experiment was conducted to study the effect of depth of ploughing, placement of fertilisers and doses of plant nutrients on yield of starch content of potato. It was observed that deep ploughing (10 inches deep) or 5 inches deep victory ploughing followed by country ploughing or 5 inches deep country ploughing showed no difference in yield. Top dressing of fertilisers gave slightly better response than placement. Highest yield was obtained with 160 lb. N+80 lb. P+O+80 lb K applied in the form of ammonium sulphate, single superphosphate and sulphate of potash. Application of complete fertiliser gave higher starch content than application of nitrogen alone.

21. Sahay, K. N. *Response of linseed varieties to levels of nitrogen and phosphorus and mode of application*

The experiment was laid out to study the differential response of three linseed varieties to levels of nitrogen and phosphate and to mode of application. Variety R.R. 236 outyielded varieties R.R. 10 and N.P. 12. Application of 20 and 40 lb. N/acre increased linseed yield significantly though the interaction between varieties and doses of nitrogen was not observed. All the three varieties showed no response to levels of P_2O_5 Application of fertilisers 2½ inches below the seed gave better response than broadcast application. A dose of 40 lb. N/acre was found to be optimum dose for all the varieties.

22. Sen Gupta, A. K. *Varietal response to nitrogen in sugarcane.*

Performance of six sugarcane varieties, namely, B.O. II, Co. 312, Co. 647, Co. 739 and Co. 797 was studied at 40, 80, and 120 lb. N per acre applied in the form of sulphate of ammonia. According to the yield performance, the varieties may be arranged in the following order: Co. 647, Co. 797, Co. 695, B.O. II, Co. 789, Co. 312, Co. 647 produced the highest yield of 837·67 md. per acre, closely followed by Co. 797 with 780·61 md. per acre. Juice quality of Co. 647 and Co. 739 was poor in comparison to the other four varieties. Hence, as a producer of total commercial cane sugar Co. 797 was found to be more desirable than Co. 647, although the difference between the varieties in this respect was not significant. Linear response was obtained upto 120 lb. N/acre. The maximum net profit of Rs. 119 was obtained with a dose of 120 lb. N/acre.

23. Shanware, P. G. *Study of the effect of irrigation, nitrogen and seed rate in sugarcane.*

Effect of three agronomic factors, namely, delta of irrigation, doses of nitrogen and seed rate was studied on sugarcane yield. Applying irrigation water upto 60 inches and 75 inches gave higher yield than 45 inches, however, the best yield was obtained with 60 inches. The response to doses of irrigation water was of quadratic nature. Significant increase in

yield was decorded with each increment of nitrogen does (does were 60, 80 and 120 lb. N/acre). Similarly higher seed rates of 60 and 75 md. per acre gave more yield than 45 md. per acre. The response to seed rates was of linear nature. The optimum requirement of sugarcane under Delhi condition was found to be 120 lb. N/acre, 60 inches of irrigation water and 60 md. of seed rate.

24. Sharma, S. K. *A study of effects of villagers' participation in rural development; its limitations and suggestions for improvement*

From the intensive study of six villages, it was observed that the use of improved varieties and implements increased with the increase in size of land holding. Effectiveness of demonstration was highest compared to other extension methods. The effectiveness of various extension methods was demonstration 38·29 per cent., individual approach 23·21 per cent., indirect effect 13·38 per cent. and field days 10·83 per cent. For development activities other than in agriculture sphere, the cultivators contributed more in cash than in labour, but the farmers participated in less degree in such activities.

25. Sethi, M. L. *Investigations on the extension methods already employed to intensify the use of manures and fertilisers; their limitations and suggested lines of improvement*

To find out the role played by the various extension methods used in bringing out a greater adoption of fertiliser practices, knowledge gained through these methods, attitude towards these methods and relationship between the combinations of the methods, six villages of intensive cultivation scheme area were selected at random and 77 cultivators were interviewed.

A large number of cultivators (50 per cent. of those interviewed) who had seen demonstrations were using fertilisers as compared to those who had not seen them (14·3 per cent. of those who had not seen). Majority of the cultivators (83·2 per cent.), on whose fields demonstrations were laid out, were using fertilisers. It was further observed that the consumption of the fertilisers has increased since the start of the Intensive Cultivation Scheme in the villages and ammonium sulphate was the most popular fertiliser. The practice of green manuring has not made much headway while the pits for making F.Y.M. were not correctly filled.

26. Sikka, H. C. *Agronomic studies on relative merits of various crop rotations*

The rotation *green manure-wheat-fallow-potato-sugarcane*, which received heavy doses of manure and fertilisers in addition to green manure and had lower intensity of cropping (100 per cent), consequently increased the yield of sugarcane (21·8 per cent. and 20·8 per cent.) over the other two common rotations, *viz.*, *maize-potato-sugarcane* or *fallow-wheat-cotton-fallow-sugarcane*. The green yield of maize in the rotation treatment where it followed a cereal crop of wheat, was lower by 4·48, 3·85 and 3·20 md. per acre than in the rotation where it followed potato, sugarcane or peas respectively. In the rotation where maize and cowpeas (for green fodder) had followed berseem, the maize yield was significantly higher than in the rotation where it was preceded by wheat. Cotton yield was not affected by different rotation treatments.

27. Singh, J. *A study of the agricultural extension methods in relation to achievements and the limitations towards agricultural development in the Nangloi extension area.*

The introduction of improved varieties of wheat, vegetables, barley and oats made considerable progress. These crops were in the saturation stage of their development, while gram and *bajra* were still in their demonstration stage and sugarcane and *Jowar* in their experimental stage. It was further observed that cultivators were becoming fertiliser minded but the only fertiliser common with the cultivators was ammonium sulphate due to its being easily available and giving conspicuous results in the initial years. In the absence of other alternative sources, cow dung was being liberally used as fuel. Composting was not practised, although the F.Y.M. was generally stored in pits. Green manuring as a practice of replenishing soil fertility has started becoming popular.

Division of Botany

28. Ahluwalia, B. S. *Study of genetic diversity in relation to specific combining ability of inbred lines of maize (Zea mays L.).*

All the available single crosses among a group of five Indian and three exotic inbreds were compared. It was found that foreign x Indian combination, on an average, significantly outyielded the rest. The study on the specific combining ability showed that certain inbreds combined well in one specific combination, while certain others combined well in more than one combination to produce high yielding crosses. It was further found that 20 single crosses, 12 three way and 2 double crosses significantly outyielded the local check K.T. 41.

29. Bhattacharya, B. K. *Genetics or rice (Oryza sativa L.) inheritance of anthocyanin piymentation and other morphological characters in inter-varietal crosses within Indica group*

In crosses amongst the *Indica* group, 14 plants' parts for inheritance of pigmentation and 8 parts for inheritance of morphological characters were selected and studied in F_2 from 9 cross combinations. In general, there was no linkage between the pigment genes and various morphological characters studied, except between dwarf character and pigmentation in sterile glume and between pigment in apiculus and absence of auricle, ligule and juncture. There is urgent need for suitable formulas for working out linkage relationship.

30. Chopra V. L. (*a*) *Induction of male sterility in some crop plants;* (*b*) *Induction of polyploidy in water-melon and musk-melon*

(a) Effects of a number of concentrations of six chemicals, *viz.*, maleic hydrazide (MH), triiodobenzoic acid (TIBA), nucleic acid, sodium nucleate, thymine and uracil, on root tip mitosis in *Allium cepa* and microsporogenesis in wheat, onion and tomato were studied. Complete pollen sterility, without improvement in seed setting capacity, was induced in tomato by spraying young plants with 50 p.p.m. and 100 p.p.m. MH. In wheat, 250 p.p.m. MH induced complete pollen sterility when the chemical was sprayed once or twice before the flag leaf emergence. In onion, all the chemicals tried gave complete sterility at the various concentrations tried. (b) Tetraploids of water-melon and musk-melon were obtained

by treatment of seedings with an emulsion comprising of 2 per cent. colchichine, stearic acid, morpholine and lanolin. Data relating to the cytological behaviour and fruit and seed-setting in tetraploids are given and the problem in the production of seedless water-melons are discussed.

31. Dabral, K. C. *A comparative study of drought resistance of some Durum and Vulgare wheats*

Two experiments under irrigated and unirrigated conditions were laid out at Indore and Delhi simultaneously. Among the varieties tested, all were *durum* and 3 *vulgare* wheats. Observations on plant counts, shoot counts per unit length, shoots per plant, ear length, ear number, grain yield, grain yield per ear, spikelet number, grain number per ear and 1,000 grain weight were taken. Correlation analysis indicated that ear number has got the maximum influence on yield. Red-grained *durums* were superior in yield to amber-grained ones but this needs further confirmation.

32. Dave, H. R. *Inheritance of rust resistance and other characters in wheat*

The inheritance of rust resistance was studied in (i) F_3 generation of two interspecific crosses and (ii) in F_2 and F generations of two intervarietal crosses. In the former, it was found that susceptibility was inherited as a dominant character controlled by two factor pairs. Inheritance of hairiness, prominent keel, pubescene of the glumes etc., was also worked out. In the latter cross early growth habit showed incomplete dominance due to a single factor pair. All the four characters studied were found to be independently inherited.

33. Dey, B. B. *Studies on techniques for rapid determination of viability and germinating capacity of crop seeds*

Rapid tests for determining the germination capacity of seeds were carried out with the following chemicals: sodium biselenite, 2, 3, 5 triphenyl, tetrazolium bromide, sodium dinitrobenzene, tellurium bromide and tellurium chloride. Seeds of 20 crop plants, important among which were maize, oats, wheat, rye, gram, pea and chilli were tested. The results of each chemical with separate crop are discussed thoroughly.

34. Hooroo, L. S. *Heterosis: its utilisation with special reference to tomato (Lycopersicum esculentum Mill)—a review*

A summarised account firstly of the various genetical and physiological theories advanced to explain the phenomenon of heterosis and secondly of the practical utilisation of heterosis in vegetable improvement has been dealt in this review. A detailed discussion of the manifestation of hybrid vigour in relation to the improvement of yield of tomato is given. It is suggested that determination of the combining ability of various varieties is a prerequisite for the maximum exploitation of hybrid vigour.

35. Jha, K. K. *Monocomic analysis of some characters in wheat*

By using 'Chinese spring' monosomic lines, the genetics of awning, glume beak, node pubescence and ear shape was studied in the varieties N.P. 790, E. 952 and E. 220. The genes for glume beak appear to be the same as for awning or they may be closely linked genes. In the

variety N.P. 790, a gene Ba2 allelic to gene B2, was identified on chromosome X. The location of genes hd. and bl, on chromosome VIII and IX was confirmed.

36. Karibasappa, B. K. *Cytogenetical studies in the genus Oryza—Cytology of two diploid and three tetraploid wild species and chromosome variants*

Cytogenetical studies were carried out in the wild species *Oryza australiensis, O. latifolia, O. alta* and *O. ridlevi.* Chromosome variants in *O. officinalis* and a haploid, a triploid and aneuploids of *O. sativa* were also studied. The significant cytological features like secondary associations, hexa-valent formation in the triploid, loose pairing in the haploid etc., support the theory of polyploid origin of *Oryza.* The study has opened up a new line of work in correlating chromosomal changes with the evolution of geographical varieties.

37. Majumdar, P. K. *I. Use of ionizing radiation in the improvement of ornamental plants. II. Studies on radiation sensitivity of chromosomes*

I. Dry seeds of 10 different annuals were irradiated with two X-ray dosages and a number of phenotypic changes were observed. These include a change in flower form from single to double in chrysanthemum, an increase in number of ray florets from 9 to 13 in cosmos, and a change in colour in pansy and cynoglossum.

II. X-ray fractionation experiments with barley roots show that the effect of separating an X-ray dose of 24,000r into two equal fractions is that breaks remain open for reunion and the first dose has a depressing effect.

38. Mehta, N. P. *Study of comparative performance of red and amber-grained selections of wheat under rainfed conditions at Delhi and studies on the mode of inheritance of seeding reaction to two races of black rust of wheat in certain inter-varietal crosses of Triticum aestivum*

Thirty six pure red-grained, thirty six pure amber-grained and forty selections segregating for grain colour, randomly obtained from F5 generation of six intervarietal crosses of *T. aestivum* were tested for studying their comparative performance under rainfed conditions. Red-grained segregates offered better scope for selection. In the second part of the thesis, the mode of inheritance of reaction to race 15 of black rust was investigated in nine intervarietal crosses of *T. aestivum.* Different inheritance ratios were obtained for resistance to the same race in different varieties.

39. Pathak, S. G. *Studies on hybrid vigour in intervarietal crosses of Gossypium hirsutum L.*

Twelve F^1 hybrids were studied for hybrid vigour. Individual plant observations were recorded for several characters. Significant heterosis in initial plant height was observed in 3 hybrids. This held good even at maturity. Covariance analysis showed 8 hybrids recording increased yield over the superior parent. Combining ability was also studied.

40. Qureshi, R. H. *Study of varietal differences in Gossypium hirsutum L. with regard to neppiness and factors contributing to nep formation*

Fourteen varieties of *G. hirustum* L. were studied with regard to neppines and factors contributing to nep formation. The material was grown in progeny rows, replicated four times. Statistically significant differences were observed between the varieties with regard to nep, and other characters leading to nep formation. The significance of the results in relation to breeding cotton free from neppiness has been discussed.

41. Rao, P. H. *Varietal reaction of wheat to conditions of deficient soil moisture*

One hundred and seven varieties of wheat, both exotic and indigenous, were studied in respect of different plant characters with a view to finding out some characters associated with yield under conditions of soil drought. The characters studied included tiller number, ear number, grain number, 1000 kernel weight and yield. None of the varieties showed high value for all the characters desirable for drought resistance. These studies indicate the possibility of combining high values of characters like ear number and 1000 kernel weight in one variety by suitable hybridiation.

42. Sankaranarayanan, K. *Studies of the effects of antibiotics and other chemicals on the growth of excised plant embryos in artificial media*

Seven chemicals, namely, penicillin, chloromycetin, terramycin, streptomycin, isonicotinic acid hydrazide, sulphonamide and gibberellic acid were tried for their effect on the growth of excised tomato embryos grown *in vitro*. The results obtained showed that isonicotinic acid hydrazide and gibberellic acid stimulated the growth of young embryos, while the rest had a depressing effect.

43. Sharma, J. N. *Induction of polyploidy in some ornamental plants*

Experiments designed to induce doubling of chromsome number by the application of colchicine in a number of common garden annuals including cosmos, coreopsis, tagetes, dianthus, petunia, antirrhinum and phlox have been described and the results obtained have been discussed. Each of the tetraploids of the seven annuals produced on an average bigger flower, with increased number of flowers per plant. Except phlox all other garden annuals studied offer considerable promise for being introduced as tetraploid strains.

44. Subramanyam, K. N. *I. Studies in induced tetraploids of berseem (Trifolium alenandrinum L.) and senji (Melilotus indica All.). II. Cytogenetical studies in some economic grasses*

The Study was carried out in C^3 generation of tetraploids of berseem and *senji*. Auto-tetraploids of berseem showed 'gigas' expression in many morphological characters like height, number of tillers and branches. In auto-tetraploids of berseem and *senji*, a number of multivalent chromosome configurations and abnormalities were observed. Some plants of berseem showed chromosome mosaic formation, with the

chromosome number 17 to 32. Different genetical and sytological techniques for the improvement of seed fertility including polyploidy cum radiation have been discussed.

Cytological studies of 12 species of grasses belonging to 4 genera in the tribe *Andropogoneae* were undertaken, and the general trend of evolution in the family *Gramineae* has been discussed.

45. Tiwary, N. P. *Study of Japonica X Indica hybrids of rice (Oryza sativa, L.) under normal and high levels of soil fertility and the possibilities of breeding strains suitable for the two levels.*

Fourteen *Japnonica* x *Indica* cross combinations (comprising 49 progenies) and eleven *Indica* varieties were studied under normal and high levels of soil fertility. Plant height, total tillers per plant and the number of ear bearing tillers, straw weight, yield of grain and protein content in grain increased significantly at high fertility level in the *Japonica-Indica* derivatives, while ear characters, flowering-duration, 500 grain weight, sterility percentage, and cooking equality did not show significant difference at the two levels, although many of them showed a trend for increase at the higher level.

46. Venkataswamy, T. *Genetical and cytological studies of sterility in inter-racial hybrids of rice (Oryza sativa L.)*

Some varieties of *Indica* and *Japonica* and their hybrid progenies were studied to investigate into the causes of semi-sterility. The effect of environment on hybrid sterility is marked and the response depends upon the genotype of the segregating population. The study shows that analysis of hybrid sterility is a method of tracing the evolution of *Japonica* subspecies by gene mutations and chromosomal structural changes. The semi-sterile cutlures are shown to be a rich source of chromosome variants and gene mutants.

47. Wanjari, M. R. *Heritability and genetic correlation between characters contributing to yield in linseed (Linum usitatissimum L.)*

Twenty-seven families of *L. usitatissimum* including 24 indigenous and 3 exotic ones with three progenies in each family were grown in compact family block design with six replications. Heritability observations for a number of characters showed that for characters showing high heritability selection could be done on the direct phenotypic basis, but selection with regard to characters showing low heritability would have to be based on the progeny row technique.

48. Sethi, K. L. *Genetic variability in barley*

One hundred and twenty-one varieties of barley were studied for some quantitative characters. A study of 15 important qualitative characters was made in 98 varieties. Mean values and co-efficient of variability were worked out for several agronomic characters. Correlation studies indicated highly positive correlations between yield, number of ears per plant and 250 kernel weight.

49. Bera, B. K. *Thermal tolerance in Aparteles angaleti Mueseback at different humidities*

Under laboratory conditions, temperatures ranging from 40°C to 45°C were found to be highly fatal to both the sexes of the parasites depending on the exposure periods and humidity. At 30 and 50 per cent relative humidity, higher mortalities were observed with longer exposures at 40°, 42° and 43°C. But at the same temperatures, the tolerance was found to increase at 70 and 90 per cent. relative humidity. Thermal tolerance was minimum at 45°C and 90 per cent. relative humidity. Higher mortality was associated with longer exposure periods at all temperatures. Females were relatively more tolerant to high temperatures than the males.

Under field conditions, however, the mortality was found to be highly correlated with maximum temperature and relative humidity (at 2 P.M.), but with the elimination of the effect of relative humidity, no association was detected between mortality and maximum temperature. On the contrary, the relative humidity was found to be highly correlated to mortality even after the elimination of the effect of maximum temperature.

Females were significantly more tolerant to the adverse climatic conditions than the male parasites.

50. Das, J. N. *Taxomomic studies on the Indian membracidae*

A survey of the membracid fauna of Delhi has brought to light four new species belonging to the genera *Tricentrus*, *Leptocentrus* and *Otinotus*. These have been named as *Tricentrus lineraris*, sp. nov. (on lucerne), *Leptocentrus aeglevorous*, sp. n. (on *Aegle marmelos*) and *L. narayani*, sp. n. (on *Zizyphus* sp.) and *Otinotus tamarixus*, sp. n. (on *Tamarix gallica*). In addition to these, thirteen known Indian species of membracids belonging to the genera *Oxyrhacis*, *Tricentrus*, *Leptocentrus*, *Otinotus*, *Coccosterphus* and *Gargara* were recorded in Delhi for the first time. Another unrecorded species found on *Cestrum diurnum* in Coimbatore was named *Leptocentrus coimbatorensis*, sp. n.

Two species of membracids *Anchon pilosum* and *A. rectangulatum*, maintained in the National Pusa collection, I.A.R.I., New Delhi were reassigned to a new genus *Anchonomorpha* gen. n. under the tribe *Leptocentrini* on account of the presence of four apical cells in the hind wing.

51. Joshi, S. A. *Studies in resistance to some of the insecticides by beneficial insect (Parasites)*

The effect of repeated treatments of sub-lethal concentrations of insecticides on successive surviving generations of *Bracon brevicornis* Wesmael (*Braconidae*: Hym.) was studied for eleven generations with p-p' DDT and six generations with lingane. Critical bioassay of the selected strains and the original ones was carried out with p-p' DDT, lindane and aldrin. There was a gradual development of resistance from generation to generation. In each generation, variations of fluctuations in the inheritance of resistance were recorded but there was found an unmistakable trend to the inheritance of resistance shown in particular by the shift in the

median lethal concentration of the DDT-selected strain. Inheritance of resistance was discussed in the light of postulates of (a) dynamic variation, (b) mutation.

52. Kathuria, D. S. *Effect of temperature and humidity on the rate of development of Bracon (Microbracon) gelechiae* (Ash on *potato tuber moth Gndrimoschema operculelia Zell.*)

Investigations were carried out on the rate of development of *Bracon (Microbracon) gelechiae* Ash. under different combinations of temperature and humidity under laboratory conditions. The lower and upper limits of temperature for the egg were found to be between 5-10°C and 35-40°C respectively. The incubation periods of eggs were 23·4 and 0·7 days at 10° and 35°C respectively at 35 per cent R.H., while an increase in R. H. to 75 per cent decreased these durations to 16·4 and 0·6 days. The lower and upper limits for pupea were nearer to 15° and 40°C. The larval periods were 5·4 days at 15°C, 2·4 days at 35°C at 74 per cent R. H. and 2·4 days at 20°C and 2·0 days at 40°C at 35 per cent R.H. The pupal periods were 11·7 days at 20°C, 5·0 days at 35°C with 35 per R.H., and 15·5 days at 15°C and 3·8 days at 35°C with 75 per cent R.H. The equation, $Y = 13:01e—0.001065\ (96.7\text{-}t)^2$ was fitted to the periods required for the completion of full life-cycle. The longevity period of 26 days was the longest at 10°C and of 3 days was the shortest at 35°C. The oviposition was maximum at 25°C.

53. Kumar, S. S. *Effect of temperature and host density on the rate of increase of population of Bracon Brevicornis* Wesmael

It was found that the effective range of temperature for oviposition of the parasite was between 15°C and 40°C. Oviposition increased with rise in temperature from 20°C to 35°C and decreased at 38°C. Efficient distribution of the progeny occurred only at 25° and 30°C. The ability of the parasite to contact its hosts was affected at 20° and 38°C.

Host density did not influence the oviposition of the parasite within the given period, and it laid more or less constant number of eggs. Number of hosts utilised by the parasite in the given period did not depend upon the density of the host but upon absolute number of hosts available to the parasite in the given universe. Efficient distribution of progeny occurred when there were 12 to 15 hosts present in the environment. Thus efficiency was impaired when the host number in the environment was very low and greater super-parasition occurred. When the area of search approached in the limits of search of the parasite, the efficiency in distributing the progency was also affected a little.

54. Man Singh, A. *Relative resistance of different stages of desert locust (Schistocerca gregaria Forsk.) to insecticidal injections*

The toxicity of various insecticides injected in the haemocoel of II, III and IV stage hoppers and adults of the desert locust, *Schistocerca gregaria* Forsk., was found in all the stages to be in the following descending order: aldrin, parathion, dieldrin, chlordane, endrin, isodrin, diazinon, lindane, HETP, systox, pestox, malathion, toxathion, toxaphene pp/-DDT, nicotine sulphate.

The III and IV stage hoppers and male adults were found to be more resistant than those of the II stage by 1·47, 1·6 and 22·1 times to aldrin, 1·54, 1·8 and 18·1 times to dieldrin, 1·7, 3·5 and 18·1 times to endrin, and 2·09, 2·8 and 21·6 times to isodrin. The respective resistance of III and IV stages exceeded that of the II stage by 2·14 and 2·32, 1·5 and 2·4, 1·7 and 1·9, 1·25 and 1·4, 1·19 and 1·3, 1·33 and 2·7, 1·09 and 1·6, 1·33 and 1·38, 1·47 and 9·5, and 1·7 and 9·3 times in the case of parathion, diazinon, lindane, HETP, systox, pestox, malathion, toxaphene, pp-DDT and nicotine sulphate respectively.

The female adults were found to be about 1·2 to 1·8 times more resistant than the males.

55. Shri N. *Efficacy of insecticidal films to control just-hatched larvae of interval feeders*

The figures of relative toxicity of different organic insecticides to just-hatched larvae of *Chilo Zonellus* Swin, were worked out using IC 50 as criterion and taking that of DDT as 1. Parathion, lindane, malathion, endrin, dieldrin, isodrin proved 123, 14, 12, 11, 9, 6 and 3 times more toxic than DDT respectively, while toxaphene and chlordane proved 0·4 and 0·3 time bro toxic.

56. Nigam, M. P. *Effect of temperature on the uptake and elimination of HCN fumigant by insects* (Larvae *corcyra cephalonica straint*)

These investigations consisted of studying the effect of temperature on the uptake, recovery and elimination of the fumigant and mortality of the insects during pre-fumigation and post-fumigation periods. The uptake, recovery and elimination of the fumigant and mortality of the insects during all the three treatment periods were recorded higher at high temperature (30°C) as compared to lower temperatures (12·5° and 20°C), except elimination during fumigation treatments and recovery during post-fumigation treatments which proved to be contrary.

57. Pawar, J. G. *Taxonomic studies on the Indian Aphididae*

As a result of these studies, twenty-eight species of aphids have been recorded from both cultivated and non-cultivated plants of Delhi, thus adding thirteen new species to the fifteen already known. A new genus, unrecorded so far in literature has been named *Ceratopemphigiella,* gen. nov. with *Ceratopemphigiella delhieinsis,* sp. nov. as its type. This genus is closely related to *Ceratopemphigus* Schouteden and *Prociphilus* Koch, but differing from both these in having the antenual sensoria limited to the third and fourth segments only. Another interesting record is *Brachyunguis calotropicus,* sp. nov. found breeding in the flower-heads of *Calotropis* sp., an aphid differing from all the other recorded species of the genus by the absence of any sclerotised patches on the body. *Saltusaphis africana* Eastop, very recently described species from East Africa, has also been recorded from Delhi, the record being second in the world.

58. Sharma, S. K. *Fumigation of some stored product pests*

Six fumigants were tried against adults of *Tribolium castaneum* Hb. and grubs of *Trogoderma granarium* Everts in empty space and in presence of wheat, shelled and unshelled groundnuts and cashewnuts.

T. granarium was more resistant than *T. castaneum* to all fumigants tested under all the conditions. Methyl bromide was found to be most tonic to *T. castaneum* in empty space followed by acrylcn, ethylene dibromide, ethylene dibromide and carbon tetrachloride mixture, carbon disulphide and carbon tetrachloride. In case of *T. granarium*, the ranking of fumigants was same except that the position of carbon disulphide and ethylene dibromide was reversed.

The order of efficacy of various fumigants against *T. granarium* in presence of various commodities was the same as in empty space. The position of fumigants when tested against *T. castaneum* in presence of various commodities was the same as in empty space except when these insects were fumigated in presence of shelled groundnuts. Carbon disulphide which was more toxic to *T. castaneum* in empty space was found to be less effective in presence of shelled groundnuts.

Wheat was found to be least sorptive material in comparison to other commodities for all the fumigants tested and cashewnut was highly sorptive for carbon disulphide, ethylene dibromide and carbon tetrachloride mixture, ethylene dibromide and carbon tetrachloride, whereas unshelled groundnuts were highly sorptive for methyl bromide and acrylon.

Division of Mycology and Plant Pathology

59. Dhanraj, K. S. *Sector formation in Colletotrichum Falcatum Went and detailed studies of the individual variants*

Pour plate method was used to obtain variants, some of which, generally mycelial, were stable. One stable variant was obtained from the culture grown on Richard's medium. Some 2½ months old cultures of *C. falcatum* produced temporary sectors which reverted to the parent type in the following generation. Two grams of zinc sulphate per litre of oatmeal medium brought about variation in *C. falcatum*. Exposure to ultra-violet rays for four hours also produced a stable variant with yellow pigmentation. Nitrogen mustard (MBA) was very effective in inducing sector formation in *C. falcatum*, the effective dosage being 0·01 mM. to 0·1 mM. The variants differed considerably as regards their rate of growth and cultural characters on the different media used.

60. Pingaley, K. V. *A mosaic disease of soybean [Glycine max (L) Merrill]*

The investigations on a mosaic disease of soybean [*Clycine max* (*L.*) Merrill] characterised by a typical mosaic pattern of irregular light and dark green areas on the leaves and blistering and deformation of the leaf lamina showed that the disease was of virus origin, the casual virus being transmitted from diseased to healthy plants by sap-inoculation with expressed juice of mosaic affected leaves. The host range studies on 65 species belonging to 13 families showed that the virus was restricted to soybean only.

The virus was found to have a thermal death point of 60° to 62°C, dilution end point between 1: 1,000 and 1:5,000 and a longevity *in vitro* of 3 to 4 days and 5 to 6 days at room temperatures (59°-65°F, 60°-72°F, 80°-96°F and 84°-98°F) and at frigidaire temperature (44·6° to 50°F) respectively. The virus was inactivated in the infected leaves desiccated at room temperature for 8 days and in the standard extract (1:1) by an exposure of 2 hours ultra-violet irradiation.

Four species of aphids *viz. Aphis gossypii* Glov., *Myzus persicae* Sulz., *Aphis Craccivora* Koch. and *Lipaphis erysimi* Kalt. were found to be the vectors of the virus. Transmission through the seed of diseased plants was determined, the percentage varying from 2·70 to 7·89 in different lots. The casual virus was identified as sopbean mosaic virus, Gardner and Kendrick (1921) or soybean virus 1 according to Pierce (1935) or *Soja* virus 1 according to K. M. Smith (1937).

61. Rajagopalan, K. *Bacterial leaf spot of chilli*

A bacterial leaf of chilli was observed to cause severe damage to the chilli crop in the Botany Division, IARI, during September, 1956. The pathogen was isolated and its pathogenicity proved on chilli plants. Detailed studies of the organism showed that it was *Xanthomonas vesicatoria* (*Doidge*) Dowson which had been earlier reported from Poona. Delhi isolate was found to be identical with the Poona isolate in all characters.

Nutritional studies of the pathogen showed that glucose and peptone were the best sources of carbon and nitrogen respectively. Amino-acids were utilised by the organism as sources of both carbon and nitrogen. In host-range studies, the pathogen was found to infect *Lycopersicon esculentum,* L. *pimpinellifolium* and *Solanum nigrum.* In the varietal resistance tests, all the 26 varieties tested were found to be susceptible, although Puri orange showed some degree of tolerance to the disease. The pathogen was found to survive in seeds and fallen leaves, but not in soil. The disease appeared to be favoured by high temperature.

A bacteriophage for *X. vesicatoria* was isolated from the diseased leaves of chilli. Attempts to isolate a phage from soil and seeds were not successful.

62. Reddy, A. R. *Studies on Indigofera rust*

The rust (*Uromyces indigoferae* Syn. *U. orientalis*) on *Indigofera linifolia* is found in and around Delhi. During the course of these investigations, rust samples were collected from various parts of India and *I. tinctoria L.* at Bapatla was found for the first time to harbour a rust which was identified as *U. indigoferae.*

The rust (*Uromyces indigoferae*) was found to be autoecious. Uredospores germinate at a temperature range of 10°-35°C with 18°-25°C as optimum. They remained viable for 17-19 weeks at 8°-10°C, 15 weeks under natural conditions and for 48 hours at 60°C. The teleutospores of the rust germinated readily at a temperature of 15°-37°C, the optimum being 18°-20°C. The teleutospores of *U. indigoferae on I. linifolia* retained their viability for more than 15 months at 8°-10°C (Frigidaire), for more than a year at room temperature and for nearly a fortnight at 60°C. Viable teleutospores were found all the year round in natural conditions. Perpetuation of the rust was mainly through *uredospores.* The possibility of existence of a functional alternate host has not, however, been ruled out.

On the basis of the morphological, pathological and germination studies of spores, it has been suggested that the correct name of the fungus should be *U. indigoferae* Diet. & Holw. (Syn. *U. orientalis* Syd.), having a very restricted host range. Pathogenicity studies revealed the presence of two forms namely *Uromyces indigoferae* f. sp. *linifoliae* and *U. indigoferae* f. sp. *tinctoriae.*

63. Sahani, M. L. *Studies on sugarcane rust in India*

Sugarcane rust which has come into prominence due to recent rust epiphytotics in India, has always been considered as a disease of minor importance in the past. Severe outbreaks of this disease have been reported on Co. S. 510 from Uttar Pradesh and Co. 475 from Bombay.

Sugarcane rust characterised by elongated pustules along the linear axix of the affected leaf, produce mostly the uredospores, the teleutospore production being sparse. The uredospores from different localities measured 29·6 to 31·5u in length and 20·3 to 22·4u in breadth. These were found to germinate best at 18 to 20°C and remain viable for 10 to 12 weeks at 8-10°C. The germination of teleutospores of this rust was observed at 18°C to 25°C, the optimum being at about 20°C. The percentage of germination was, however, very low. A short period of dormancy in teleutospores was also observed. Inoculation of sugarcane with germinating teleutospores revealed that this rust is not autoecious.

Rusts on grasses allied to sugarcane *viz.*, *Saccharum spontaneum*, *S. munja*, *S. arundinaceum* and *Edianthus fulvus* were also similarly studied. Gross inoculation tests with these rusts showed that *S. spontaneum* and *Erianthus* rust could successfully infect sugarcane. Sugarcane rust, on the other hand, could be transferred to *S. Spontaneum.*

As a result of varietal resistance trials Co. S. 510 was found to be the most susceptible among the 22 varieties tested, though Co. S. 186 and Co. 513 also got infected mildly.

64. Sastry, K. S. M. *Studies on the relationship of chilli mosaic virus and its vector, Aphis gossypii Glover*

Viruliferous aphid, even singly, was capable of transmitting the virus to healthy chilli plants, although the maximum percentage of infection was caused by groups of 15 aphids. The acquisition threshold or the minimum acquisition feeding period required by the non-viruliferous aphids to acquire the virus from a diseased plant was 30 seconds, but the maximum number of infections were obtained with an optimum feeding period of 5 minutes. The pre-acquisition starvation of the aphids increased the efficiency of the vector only when sort acquisition feeding periods (up to 5 minutes) were given.

The inoculation threshold or the minimum feeding period required by the viruliferous aphids to transmit the virus to healthy test plants was also 30 seconds. The post-infection starvation did not show any beneficial effect on the ability of the vector to transmit the virus. On the contrary, the number of infections obtained decreased progressively with the increase in the post-infection fasting period.

The serial transfers of single viruliferous aphids to successive healthy chilli plants showed that the virus was typically of the non-persistant type Both alate (winged) and apterous (non-winged) forms of the aphid were found to be equally efficient in transmitting the virus. In addition to *Aphis gossypii* Glover, the chilli mosaic virus was found to be transmitted by *Myzus persicae* Sulz and *Aphis evonymi* Fabr.

65. Sushil Kumar. *Physiological studies on Lophortrichus ampulus Benj*

The optimum pH. and temperature ranges for the growth and sporulation of the fungus were found to be 6·5 to 7·0 and 28° to 30°C, respectively. Among the carbon sources, sodium acetate and maltose supported the maximum growth. Mannose, starch, glucose, fructose, glycogen, sodium citrate and trehalose were intermediate sources. Rhamnose was the poorest source and sorbose did not support growth at all. None of the above carbon sources favoured sporulation. Lactose and salicin stimulated the maximum perithecial formation. Glycine, mannitol, raffinose and sucrose were the only other sources in order of their decreasing ability to favour sporulation. The growth was feeble in all the carbon sources which supported sporulation.

The fungus was able to utilise nitrites, nitrates, ammoniacal and organic compounds of nitrogen. Nitrates were the best among inorganic sources of nitrogen. All the amino-acids, except asparagine and valine, could induce sporulation provided the medium was supplemented with a suitable carbon source and vitamins. Glutamic acid, serine, adenosine, cystein hydrochloride were the best sources of nitrogen to induce maximum sporulation. The rate of growth was, however, constant in all the cases.

In absence of magnesium, the growth was less and the perithecia were few and immature. Addition of calcium salt to the medium having magnesium increased the intensity of sporulation. There was increase in growth in the presence of trace elements but the sporulation remained unaffected.

The concentrations of 1 mg/L thiamine and 1 g/L biotin were sufficient to induce abundant sporulation provided the medium contained a favourable source of carbon.

66. Pritam Singh. *Further studies on the biological activity of the antibiotic substance of Bacillus subtilis Cohn Emend. Prazmowski, in soil and plants*

Further studies on the production of the antibiotic principle by *B. subtilis* in soil showed that molasses was a better substitute for dextrose. Addition of molasses to soil resulted in higher yield of antibiotic, approximately five times than that of soil amended with dextrose. Addition of different leguminous root materials along with dextrose or molasses to soil greatly enhanced the production of antibiotic, however the rate being different. Maximum antibiotic was produced in pigeon pea roots supplemented soil, gram roots being next in the order. The maximum production of antibiotic in soil was found to be on the 7th day in case of nutrient solutions, the 14th day in pea and pigeon pea roots plus molasses, the 21st day in sweet clover and gram roots plus molasses and the 35th day when dextrose was used with root materials.

The butanol extract of gram root supplemented soil contained some inhibitory principle which overshadowed the bulb forming activity of the antibiotic in *Alternaria tenuis* at high concentrations.

In pot experiments, pigeon pea wilt was significantly reduced by the antibiotic principle produced by *B. subtilis* in sweet clover and gram roots supplemented soils in presence of molasses or dextrose.

The antibiotic principle was absorbed through the roots of pigeon pea seedlings and translocated to the aerial parts, when the seedlings were fed on antibiotic solution either in liquid or sand culture. It remained active in plant tissue and considerably reduced the pigeon pea wilt incidence. The higher concentrations of the antibiotic, however, were toxic to the seedlings.

67. Tiwari, M. M. *Studies on the nature of red rot resistance, infection histology of the susceptible and resistant cane varieties*

During the course of studies on the above-mentioned project an effort was made to investigate the factors responsible for the resistance or susceptibility of a sugar-cane variety to red rot. Sixteen Coimbatore cane varieties selected on the basis of their different degree of resistance to red rot, included in these studies, were Co.356, Co.532, Co.547, Co.548, Co.549, Co.K.34, Co.285, Co.419, Co.453, Co.213, Co.223, Co.299, Co.312, Co.331, Co.445.

As a result of histological studies it was observed that the growing mycelium was responsible for the spread of red rot in a sugarcane stalk. The progress of infection was traced to be through or along the vascular bundles. It was also noted that the fungus spores could not, possibly, be a source of linear spread of red rot within the stalk as little sporulation of the casual organism took place inside the cane stalk. It was found that the tissues which got involved during earlier stages of infection were almost the same in all the varieties studied whether resistant or susceptible to red rot. The only barrier for the progress of red rot infection within the stalk was found to be the nodal region.

The role of continuous vessels, which could be the avenues for the red rot fungus to pass through the nodes, was studies. An apparatus was devised to determine the continuity of vascular bundle though the nodes within a stalk. It was found that the number of continuous vessels was much more in susceptible varieties than that in the resistant ones. It was not only the number of continuous vessels but also the extent of their continuity in terms of the number of internodes traversed by them, that determined the nature of resistance of a variety, comparatively fewer number of continuous vessels in a stalk passing through a larger number of internodes being enough to make a variety susceptible.

Division of Soil Science and Agricultural Chemistry

68. Ali, M. A. *Genesis or saline alkali soils in the alluvial tracts of arid and semi-arid regions of West Uttar Pradesh*

The morphology and genesis of salt and alkali bearing soils occupying vast areas in West Uttar Pradesh were investigated for purposes of nomenclature and classification. Morphological characters revealed the accumulation of soluble salts at the surface, increase in the heaviness of texture along the depth, forming dense compact horizons with blocky structure and occurrence of lime and iron concretions in lower horizons. The predominant soluble anions were carbonates and bicarbonates. Exchangeable sodium was the most predominant cation in the exchange

complex and bore a relation to the total surface area of the soils. The soils of Mathura were classified under the saline soils of deSigmond or white alkali soils of Hilgard and those of Aligarh and Agra under the black alkali soils of Hilgard.

69. Anantharaman, P. V. *A study of fertility status of some soils growing paddy*

Most of rice soils under study were acidic in character except those from Madarihat (West Bengal) and Mysore which were slightly alkaline. The total nitrogen in surface layer of soils from Madarihat, Mainaguri. Bittangala, Hudigeri, Gajanur, Thotapally and Jorhat was rich but poor in Nevule and Trivandrum. Nitrogen content decreased along the depth of the profile, except in the case of Thotapally. Total phosphorus content was fairly high, but the available phosphorus appeared to be sufficient only in Mainaguri and Gajnur profiles. The availability of phosphorus decreased with depth in the case of Madarihat, Mainaguri, Bittangala, Hudikeri, Trivandrum, Thotapally and Jorhat, where as it increased slightly in case of Nevule and Gajanur.

70. Behera, B. *Effect of gypsum on decomposition of organic matter and nitrogen transformations in soils*

In most of the soils from Budhela, Baprola and Nilothi villages in the neighbourhood of Delhi, a mixture of farmyard manure and gypsum brought about the maximum decrease in pH. Gypsum, though in general, had no effect on the rate of decomposition of organic matter but in some cases, it recorded definite depression. It enhanced the rate of nitrification of soils having rates of nitrification lower than 2 mg. of nitrate nitrogen during a period of four weeks but this action was reversed in soils having rates higher than 2 mg. per four weeks. It did not have any marked influence on the nitrogen fixation and did not generally affect microbiological population of the soils though at certain periods, particularly during early stages, marked diminution in total counts was observed.

71. Bisen, D. C. *Foliar diagnosis studies and relative efficiency of dicalcium phosphate and single superphoshate on wheat*

A parallelogram 'a b c d' was constructed within the equilateral triangle on the basis of upper and lower limits of mean N-P-K units (N=56.0-60.7, P O_5 =9.0-12.0 and K O=35.0-27.3) in respect of best performance of yield in a pot experiment with Delhi soils. The limits thus found out coincided with the corresponding ones from field experiment. The N-P-K units of all the treatments, which received N-P-fertilisers and gave high yields both in pot and field experiments, were located in the parallelograms, while those of the low yielding treatments receiving N-fertilisers and no manure were located outside. A slight difference was found in respect of mean intensity in the case of pot experiment with Powerkheda soils, between values of the treatments of dicalcium phosphate and single superphosphate, while no difference was found in the mean N-P-K units. The N-P-K units of these two treatments were located just near to each other in trilinear graph. In respect of yield and uptake of $P_2 O_5$, single superphosphate was a little superior to dicalcium phosphate.

72. Deoras, C. M. *Comparative study of black soil and associated soils in semi-humid region*

The present investigation had for its objective a comparative study of diverse types of soils occurring in close proximity. The materials selected were four distinct groups of soils in Raipur district (M.P.), *viz.*, *Kanhar* (black), *Dorsa* (light grey), *Matasi* (yellow), and *Bhata* (red) which are more commonly observed to occur in close association, depending upon topographic situation. *Bhata* soils are usually found to occur in elevated situations (top of slopes) and *Kanhar* in the depressions, while the *Dorsa* and *Matasi* occupy the intermediate positions. Following the sequence in the topographic position, there was a regular gradation in the physical and chemical properties of these four groups, the order being *Kanhar, Dorsa, Matasi,* and *Bhata*. The *Kanhar* soils were very heavy in texture whereas the *Bhata* soils contained the lowest amount of clay. The other properties followed this order; the *Dorsa* and *Matasi* soils were intermediates between these two groups. Clay fractions of *Kanhar* black soils were dominantly montmorillonitic in nature whereas illite was the predominant clay mineral in *Matasi*. Topography appeared to be the dominantly influencing factor in the formation of these soils.

73. Dewan, H. C. *Physico-chemical studies of virgin and cultivated soils of Nabha (Punjab)*

The present investigation deals with the physical, chemical and mineralogical studies of two profiles from cultivated land, two from alkali soil and one from virgin land from the sub-tropical region of the Punjab State. The soils were sandy loam in texture. The pH was on the alkaline side in the normal profile whereas alkali soils showed pH above 9.0. The alkali soils were saturated with exchangeable sodium to the extent of 90 per cent. The normal soils however had good distribution of exchangeable cations and calcium saturation varied from 60 to 80 per cent. In some cases exchangeable magnesium was exceptionally high.

The clay minerals present in these soils were predominantly illite with an admixture of traces of montmorillonite. The base exchange capacity of clay fraction was between 30 and 40 m.e. per 100 gm. The high content of potash in the clay fraction indicated the presence of illite minerals in large quantities. The available nutrient contents indicated low fertility status of these soils.

74. Godse, N. G. *Formation of different soils on the basalt rock under varying conditions of rainfall in Bombay State*

In order to understand the genesis of soils developed on basaltic rock on the Deccan Plateau under varying rainfall conditions, seven profiles were collected from areas receiving rainfall from 18 to 107 inches. Formation of clay was observed to be related not only to the rainfall but also to the parent material. The properties generally dependent upon the clay fraction did not show much direct relation with the clay content whether the soils were developed under high or low rainfall conditions. Carbonate content, pH, distribution of silica, and deposition of iron and alumina in different horizons of the profiles showed a direct relation with rainfall. It was inferred that basaltic rock may give rise to the montmorillonitic, illitic or kaolintic types of clay mineral depending upon the rainfall conditions.

75. Goswami, N. *Effect of moisture and organic matter levels on phosphorus availability and uptake by wheat on typical soils*

The effect of moisture and organic matter levels were studied on availability and uptake of phosphorus by wheat on four typical Indian soils having different physical and chemical properties. Three levels of F.Y.M. and four levels of moisture (50%, 75%, 100% and 125%), taking moisture equivalent as 100%, were combined in a randomized design with four replications. Superphosphate tagged with P^{32} was used as a basal dose of phosphorus @ 80 lb P_2O_5 /acre.

Yield of dry matter, percentage composition of phosphorus, uptake of total and soil phosphorus increased with the increasing doses of organic matter but percentage uptake, actual uptake and percentage utilisation of the fertiliser phosphorus decreased with the increase in organic matter levels. Increase in moisture levels from 50 to 125 per cent increased yield, percentage composition of phosphorus, uptake of total soil and fertilizer phosphorus and percentage utilisation of the added fertiliser phosphorus.

In both green house as well as laboratory experiments, phosphorus availability increased with the increasing levels of organic matter. Moisture levels had no significant effect except that in alluvial soil 50% and 75% moisture increased phosphorus availability more than that with 100% or 125%. Effect of different states of the soil-dry and moist on the availability of phosphorus, indicated an increase in moist state in the red soil and dry state in the black soil, but no change in either state in alluvial and calcareous soils.

76. Gupta, V. K. *Studies on the genesis of alluvial soils of semi-arid and semi-humid tracts*

On the basis of rainfall, five profiles were selected from four places, Suratgarh and Sumerpur representing semi-arid tracts and Nawanshahr and Satna representing semi-humid tracts. The morphological features revealed that the sediments of Suratgarh are quite young (2500 years) and owe their origin to the drying up of an ancient river, Gaghr; Sumerpur sediments travelled a very short distance and indicate deposition by gravity; Nawanshahr profiles are quite mature and are old in comparison to the previous ones; Satna profile has developed on calcareous parent material. All the profiles, however, revealed that climatic and biotic factors had influenced much and the weathering was more in torlayers. Satna and Sumerpur profiles had mixed minerals of montmorillonite and beidellite types while Suratgarh and Nawanshahr soils had clay mineral of illitic nature. The mineralogical analysis supported these observations.

77. Haria, N. H.. *Fluctuations in the nutrient availability of soil with depth, seasons and stages of crop growth*

Mineralisable nitrogen showed considerable fluctuations with maximum accumulation during summer months and minimum during winter months. Similar trend of variation appeared to occur in all the seven soils, representative of different parts of the country irrespective of depth and treatments. Mineralisable nitrogen, however, decreased with depth. Chromic acid oxidation of carbon was found to vary with

seasons. pH. generally tended to increase during the winter months and decreased in summer months in all the soils. The variation of pH with the depth was not consistent in all soils. Total soluble salts appeared to increase in summer months and decrease in winter months. Considerable fluctuations were noticed in exchangeable calcium and magnesium content in all types of soils studied, but there was no regular trend of fluctuation.

78. Misra, C. P. *The role of clay-humus complexes in the fertility of some Indian soils*

The yields of wheat obtained in the soil fertility field experiments of the IARI using artificials as well as combination of artificials and organics were very significantly correlated with the product of the group I and group II clay-humus complexes in the corresponding soils. The difference between the plots showing a greater degree of response to artificials and the ones showing less was found to be in the content of their Group I complexes, the former showing more of such complexes which seem to represent the nutrients transporting mechanism of the soils concerned. The treatment with a combination of oil-cake, nitrogen, potassium and phosphorus on the infertile area was, however, found to raise its Group I and Group II complexes as well as the yields as compared to the control plots of the fertile series. This provided a clue for increasing the fertility of large areas at the Alipur Centre (Delhi) which did not respond to artificials as compared to the adjoining Nilokheri centre. The black soils of Padegaon and Saurashtra and the grey soil of Summerpur had similar values of Group I complex and the ratios of Group I to Group II complexes as these of their Russian and Canadian counterparts.

79. Mittal, O. P. *Micro-element status of typical Indian surface soils*

The alluvial, black and lateritic soils showed distinctive features in distribution of the micro-elements. The accummulation of the micro-elements in the top zones of the soils appeared to be related to their pH. The lateritic and red alluvial soils with low pH values and the black cotton soils of Hyderabad with high pH values seemed to be poor in molybdenum and cobalt. No relationship, however, was found between the major and micro-elements in these soils.

80. Mutatkar, V. K. *Carbon and nitrogen status of arid and semi-arid regions of India*

Organic carbon and nitrogen in both black as well as alluvial soils in the arid and semi-arid regions of India were found to increase with rainfall. In the case of black soil, however, a decrease was recorded with rainfall above 40 inches (or N. S. Q.-500). Organic carbon, nitrogen and C/N ratios of both the groups of soils had a negative linear relationship with temperature.

In Delhi soils, recent alluvium (*Khadar*) recorded higher carbon and nitrogen content as compared to the older alluvium (*Bangar*). Next in order were *Kohi* or hilly area and *Dabar* or low lying area. Some theoretical values of nitrogen percentages have been calculated. The present values of carbon and nitrogen in the cultivated soils being low organic matter can be built up further by suitable agronomic practices.

81. Prasad, K. K. *Physical, chemical, and mineralogical studies of black soils formed from trap rock*

Morphology of a few profiles of virgin black soils collected from Achalpur (Bombay) showed a characteristic form of A horizon, varying in depth from 36 to 42 inches with a sharp transition to C horizon (*Murram*). The colour was dark grey brown diffusing to dark brown near the boundary of yellowish brown C horizon. This is characteristic of the shallow black soils formed from trap rock. All the horizons of the profiles were alkaline in reaction, clayey in texture, calcareous in nature and showed a sharp a cumulation of clay just above the C horizon. Such clay accumulation, most likely due to mechanical eluviation, indicated the well developed nature of the profile. Physical weathering and parent material were the dominant factors in the formation of these soils.

Clay fractions were predominantly montmorillonitic as evidenced by X-ray and chemical analyses.

82. Rao, Y. N. *Comparative study of laterites and associated soils*

Laterites contained a high proportion of the total sesquioxides in free and extractable form, while the free sesquioxides formed a low percentage of the totals present in the other soils. Free sesquioxide figures were similar to those determined by dye adsorption studies in all cases except in the laterite type. The other properties showed a close relationship to the free sesquioxides, their content and nature. Cation exchange properties were not much affected by the removal of the free sesquioxides. Phosphate fixation showed a parallel variation with the active surface as indicated by dye adsorption method. Buffer effects were indicated in brown forest soil and laterites but not in the red and alluvial soils.

83. Ravikumar, V. *Genesis of alluvial soils in the arid and semi-arid tracts of West Uttar Pradesh*

Investigations on the genesis of some alluvial soils in the West Uttar Pradesh showed that although young alluvial formations *viz.*, those occurring at Agra, had no specific pedogenic characteristics, the older sediments occurring at Aligarh and Mathura showed certain horizon differentiations, involved in the process of profile development. Climate played an important role in the formation of these soils.

Illuviation was both intense and deep in all the soils studied except in those of Agra which seemed immature and showed no horizon differences.

84. Sarma, V. A. K. *Studies on the physico-chemical properties of some Indian soils with special reference to red and lateritic soils*

It has been found that on the basis of their available potassium content alone, as determined by Morgan's method, the differential response of soils to potassium fertilisers could not be accounted for. However, by taking into account their relative position in the soil sequence arranged according to their equilibrium exchangeable potassium saturation, the anomalies could be explained. The clay mineralogical makeup of the soils and the interaction between the various components were found to enable the explanation of the causes for the behaviour of the exceptions to the above relationships. The bonding energy for calcium was found to be greater than that for potassium in all the soils studied.

The electrical conductivity of various binary mixtures of sols of the oxides of iron and aluminium and clay minerals, at different pH. values, indicated strong interaction between kaolinite and nontronite in the alkaline range and between illite and montmorillonite in the acidic range, thus suggesting the formation of distinctly new species of mineral.

The results indicate the occurrence of a coating of nontronite by aluminium hydroxide in the acid range, of bentonite and illite and nontronite by ferric hydroxide, of nontronite and bentonite by illite, of bentonite and nontronite by kaolinite, and of kaolinite by bentonite.

85. Shankar, K. *The relative efficiencies of some of the new nitrogenous fertilisers*

The relative efficiencies of some of the new nitrogenous fertilisers, namely, urea, ammonium sulphate-nitrate, ammonium nitrate, ammonium nitrate and lime mixtures (giving 16, 20·5 and 25 per cent. nitrogen), ammonium chloride and liquor ammonia were studied in comparison with ammonium sulphate in laboratory as well as in pot culture. All the fertilisers were found to be excellent sources of nitrogen for wheat as judged by the highly significant increase in crop yield over the control. Ammonium nitrate-lime (25 per cent N) gave the maximum yield when applied at 30 and 60 lb. N per acre and urea did so at 90 lb. dose. Relatively smaller doses of nitrogen were more efficient than larger ones in producing additional wheat grain per unit of nitrogen applied. All treatments resulted in significantly higher recovery of nitrogen, phosphoric acid and calcium over no nitrogen treatment. Chloride bearing fertilisers, however, resulted in higher content of chloride in plants.

None of the treatments had any significant effect on the soil reaction. Nitrification in all the cases in laboratory was as efficient as in ammonium sulphate.

86. Shinde, J. E. *Phosphorus fixation and availability in some typical soils—effect of organic matter, silicates and chelating agents*

Two different soil types, alluvial (Delhi) and black cotton soil (Mhow, M.P.) were used for studying effects of organic matter, silicate and chelating agent (EDTA) on yield, uptake of total and fertiliser phosphorus by wheat. Available phosphorus and fixation capacity were studied both in green house and in laboratory incubated soils.

In alluvial soil, organic matter and silicate treatment showed increase in the yield of dry matter. EDTA, either alone or in combination with organic matter, was found to be less efficient than any other treatment irrespective of changes in available phosphorus except when it was combined with higher doses of sodium silicate without any regard to the changes in fixing capacity.

In black cotton soil, organic matter and only lower doses of sodium silicate showed beneficial effect with regard to increase in available phosphorus, reduction in fixation capacity, higher yield of dry matter and better uptake of phosphorus contributed from the soil. The higher dose of silicate showed no benefit in respect of yield and uptake even with increase in the availability of phosphorus. EDTA, alone as well as in combination with organic matter did not show any benefit, irrespective

of total uptake and changes in the available phosphorus and its fixing capacity, though the toxic influence was less pronounced than that in the alluvial soil.

In both the soils, however, combination of organic matter, EDTA at lower level and silicate at the maximum level showed the best results in all respects except in phosphorus fixing capacity.

87. Singh, D. K. *Nutritive value of plus proteins supplemented with amino-acids and vitamin B*

Two common pulses, *urid* and *arhar*, were analysed for their chemical composition and amino-acids. The percentages of protein, lysine, threoine, methionine and tryptophane in *urid* were 28·8, 1·59, 0·95, 0·35 and 0·075 while those of *arhar* were 24·12, 1·31, 0·80, 0·16 and 0·048 respectively. The supplementation of methionine significantly improved the protein efficiency ratio and biological value of *urid* and *arhar* when fed to young rats at 12 per cent protein level. Lysine significantly improved the protein efficiency ratio and biological value of *arhar* while threonine and tryptophane improved only the biological value. The availability of lysine, threonine, methionine and tryptophane in *arhar* was found to vary from 66·5 to 82·0 per cent.

Twenty micrograms of vitamin B 12 per 100 gm. of diet significantly increased the protein efficiency ratio and biological value of *arhar* when fed at 12 per cent protein level but failed to do so at 17 per cent level.

88. Singh, H. *Experiments in terpenes: study of the rate of dehydrochlorination of chlorinated compounds*

Compounds, synthesized on the basis of Diel-Alder reaction, contained C. 10—C 12 carbon skeleton, which had high toxic effects on the insects. With a view that mono-and bi-cyclic terpenes with C 10 carbon atoms should provide a useful starting point, turpentine oils from different places comprising different major fractions were chlorinated to get toxic products. The use of different catalysts was made in the process of chlorination. None of the catalysts $AlCl_3$ $FeCCl_3$, $Fecl_3$,Iodine, Benzoyl peroxide, and $NaHCO_3$, was effective. Bromination of carene and further chlorination in presence of iodine had improved the molecular density of the product. For the estimation of chlorine, use of ethyl alcohol was made to replace the highly priced material, isopropyl alcohol. A factor 1·1052 was employed for the determination of total organic chlorine with ethyl alcohol. Dehydrochlorination studies led to the results that chlorinated delta-2-carene prepared without any catalyst was at the top when compared with other products, prepared in different catalysts. This study was found to be in favour of Martin and Wain's theory as it had higher biological activity than others. Chlorinated spent turpentine oil also showed higher dehydrochlorination than other straight chlorinated turpentines. This may provide a better source for the production of more potent chlorinated insecticide.

89. Srivastava, L. L. *Processing of bones and indigenous rock phosphates into fertiliser products*

Bones were found to disintegrate completely into a paste by immersion in 10 per cent caustic soda solution for about 3 weeks. Reduction of concentration to 5 per cent necessitated longer period of immersion

for 9 weeks for complete disintegration but further reduction to 2·5 per cent decreased disintegration of bones to 33 per cent. Addition of 1 per cent sodium chloride to 2·5 per cent caustic soda was found to catalyse the disintegrating action and complete it in 3 weeks. The bone paste, washed free from alkali, dried and powdered, formed an efficient fertiliser containing high total and available phosphorus.

The following additional bone-processing treatments yielded efficient fertiliser products: (i) Bones were dissolved completely in 10 per cent. hydrochloric acid solution in 7 days. The dissolved phosphates were precipitated by neutralisation with (a) ammonia and (b) potassium hydroxide and the products dried and powdered. (ii) Bones were sandwitched between layers of sand and partially charred by heating. The treatment rendered bones friable and they could be ground to fine meal. (iii) Bones were burned to yield bone ash. (iv) Bone meal was fixed with fertilisers like ammonium sulphate and ammonium sulphate-nitrate to yield mixed N-P fertiliser products.

Processing of indigenous Trichy rock phosphate by fusion with fertiliser materials like ammonium sulphate, ammonium sulphate-nitrate and sodium nitrate yielded products of higher availability than the unprocessed rock phosphate.

GMGIPND—53 IARI—16-11-60—750